Guidelines for Benefit-Cost Analysis

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TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS i

PREFACE ii

FOREWORD iv

CHAPTER 1: BENEFIT-COST AND POLICY ANALYSIS 1

1.0 Introduction 1
1.1 Benefit-Cost and Policy Analysis 2
1.2 The Role of Economics in Public Policy Formation 3
1.3 The Social Accounting Framework 5
1.3.1 The Pareto Criterion 5
1.3.2 The Compensation Principle 6
1.3.3 Units of Measurement 7
1.4 The Market System and Public Policy 8
1.4.1 The Properly Functioning Market 8
1.4.2 Non-Market Activities 9
1.5 The Distribution of Income 10
1.5.1 Current Distribution Versus Distribution Over Time 10
1.5.2 Equity and Efficiency 11
1.6 Benefit-Cost and Policy Analysis Again 12
1.7 The Analytical Procedure 12

CHAPTER 2: EVALUATION OF THE STANDARD PROJECT 13

2.1 Introduction 13
2.2 Evaluation of the Standard Project 13
2.2.1 Definition of the Standard Project 13
2.2.2 Identification of the Referent Group 15
Guideline 16
2.2.3 Accounting for Project Benefits 17
2.2.3.1 The Benefit Measurement Principle I: Final Goods and Services 17
2.2.3.2 Measurement of Willingness-To-Pay in Practice 19
Guideline 19

2.2.3.2.1 Direct Estimation: Final Consumer Goods and Services 19
Guideline 20
2.2.3.3 The Benefit Measurement Principle II: Economic Rent 20
2.2.3.4 Measurement of Economic Rent in Practice 22
2.2.3.4.1 Direct Estimation: Intermediate Goods and Services 22
Guideline 23
2.2.3.5 The Benefit Measurement Principle III 23
2.2.4 Accounting for Project Costs 24
2.2.4.1 The Principles of Project Costing 24
2.2.4.2 Measurement of Project Costs in Practice 25
Guideline 26
2.2.5 Summary of the Foregoing 26
2.2.6 Complicating Factors 28
2.2.6.1 The Benefit Side 28
2.2.6.1.1 Technological External Economies 29
Guideline 29
2.2.6.1.2 Other Non-Marketed Benefits 29
- (a) Components of the Value of a Recreational Resource 30
- (b) Indirect Methods: Travel Cost and Transfer Cost 31
- (c) Direct Methods: User Opinion Questionnaire 34
- (d) Standard Values per Recreation Day 36
- (e) Establishing Guideline for Recreation Evaluation 37
  - Guideline 38
- (f) Option Value 38
  - Guideline 40
- (g) Existence Value 40
  - Guideline 40

2.2.6.2 The Cost Side 41
2.2.6.2.1 Indirect Production Inefficiencies-Technological External Diseconomies 41
Guideline 42
2.2.6.2.2 External Diseconomies in Consumption 42
Guideline 43

CHAPTER 3: ADJUSTMENTS FOR INFLATION, RELATIVE PRICE CHANGES, RISK AND UNCERTAINTY, UNEMPLOYMENT AND MARKET IMPERFECTIONS 44

3.1 Introduction 44
3.2 Changes in the General Price Level 44
Guideline 47
3.3 Changes in Relative Prices 47
Guideline 49

3.4 Unemployment and Excess Capacity 49
3.4.1 Unemployment and Underemployment of Labor 49
3.4.2 Excess Productive Capacity 51
Guideline 52
3.5 Imperfect Competition 52
Guideline 53
3.6 Risk and Uncertainty 53
3.6.1 Introduction 53
3.6.2 Distinction Between Risk and Uncertainty 54
3.6.3 Types of Uncertainty 54
3.6.4 Methods for Treatment of Risk 56
3.6.4.1 Method 1 58
3.6.4.2 Method 2 60
3.6.5 A Note on the Meaning of Expected Value 61
3.6.6 True Uncertainty (Uninsurable Risk) 61
3.6.7 Summary 62
Guideline 62

CHAPTER 4: DISCOUNT RATES, DISCOUNTING METHODS AND RANKING CRITERIA 63

4.1 The Discount Rate: Social Opportunity Cost (SOC) Versus Social Time Preference (STP) 63
4.1.1 Background and Definitions 63
4.1.2 Social Opportunity Cost 64
4.1.3 Social Time Preference 66
Guideline 66
4.2 Measurement of the Social Opportunity Cost of Capital 67
4.2.1 Empirical Studies 68
4.2.2 The Influence of Source of Funds on the Social Opportunity Cost of Capital 71
Guideline 71
4.2.3 A Note About the Level of the Recommended Rates 72
4.2.4 Implications of Employing the Recommended Rates 72
4.3 Ranking Criteria for Investment Decisions 73
4.3.1 Simple Investment Criteria 74
4.3.2 Net Present Value 74
4.3.3 The Benefit-Cost Ratio 76
4.3.4 Excess Benefit Over Cost Ratio 77
4.3.5 Internal Rate of Return 77
4.3.6 Comparison of the Ranking Criteria 78
4.3.7 A Normalizing Procedure for Ranking Projects 79
4.3.8.1 An Example of the Normalization Procedure 81
Guideline 84

CHAPTER 5: OPTIMIZING THE SELECTED PROJECTS 85

5.1 Introduction 85
5.2 Structural and Non-Structural Alternatives 85
Guideline 86
5.3 Optimizing Project Design and Scale 86
5.3.1 Introduction 86
5.3.2 Optimizing Scale for the Non-Staged Project 86
Guideline 88
5.3.3 Optimizing Scale for a Staged Project 88
Guideline 89
5.4 Optimal Timing of Project Construction 89
Guideline 91
5.5 Pricing the Output of Public Projects 91
5.5.1 Relationship Between Pricing and Investment Decisions 91
5.5.2 Pricing Decisions in Imperfect Markets 92
5.5.3 Objectives of Pricing 93
5.5.4 Conclusions and Recommendations 94
Guideline 96

CHAPTER 6: PROJECT EVALUATION IN THE CONTEXT OF MULTIPLE OBJECTIVES 97

6.1 Introduction 97
6.2 Types of Benefits and Costs 99
6.3 Multiple Objectives and Project Design and Selection. 100
6.3.1 Maximizing Economic Efficiency 100
6.3.2 Creating Alternative Designs with Differing Weights on the Several Objectives 102
6.3.3 Multiple Objective Planning Through Application of Opportunity Cost Concepts 102
Guideline 114
6.4 Compensation, Mitigation and Multiple Objective Planning 114
6.4.1 Introduction 114
6.4.2 Background 114
6.4.3 Compensation and Mitigation Defined 118
6.4.4 Policy Targets, Mitigation and Compensation 119
6.4.5 Compensation 121
Guideline 121
6.4.6 Principles for Determining the Extents of Mitigation 121
Guideline 123

CHAPTER 7: MISCELLANEOUS TOPICS IN BENEFIT-COST ANALYSIS 123

7.1 Contents of the Chapter 124
7.2 Taxes, Royalties and License Fees in Benefit-Cost Analysis 124

GLOSSARY OF TERMS 125

BIBLIOGRAPHY 130

APPENDICES

A. EMPIRICAL STUDIES OF REAL RATES OF RETURN IN CANADA

B. EXAMPLE COMPARISON OF RANKING OF PROJECTS BY COMPOUNDING AND DISCOUNTING METHODS

C. EXAMPLE OF APPLICATION OF GUIDELINES TO A HYPOTHETICAL PROJECT: PROPOSED DEVELOPMENT OF A SODIUM SULPHATE MINE IN METRORURITANIA

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Verne W. Loose, Chairman,
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PREFACE

The motivation behind the Guidelines for Benefit-Cost Analysis is the perceived need for consistency among benefit-cost studies performed both by government departments and private consultants. Variations in general methodology, assumptions and measurement technique characterize most existing benefit-cost studies. The purpose of the Guidelines is thus to (i) develop an understanding of benefit-cost analysis; (ii) increase understanding of how it aids the decision-maker; and (iii) establish a set of guidelines around which consistent benefit-cost studies may be constructed.

The tools of economic analysis subsumed under the title benefit-cost analysis have not yet become a generally accepted set of principles and procedures which may be applied mechanically on a repetitive and routine basis to all possible situations. Ample evidence supporting this statement can be found in reports and studies which purport to be benefit-cost evaluations but which do not conform to even the most fundamental of economic concepts. Among those studies and reports which may duly be termed benefit-cost analyses there frequently exists a wide disparity in measurement technique, assumptions and general approach. The motivation behind the Guidelines for Benefit-Cost Analysis is this lack of uniformity of method. The purpose in establishing benefit-cost guidelines which are generally accepted among government departments is to reduce the range of judgments as to measurement technique, assumptions and general approach which must be made by the individual analyst. Thus, if government departments employ the Guidelines in carrying out project appraisals performed both by staff analysts and outside consultants, greater consistency should result. This is the objective of the Guidelines for Benefit-Cost Analysis.

Some comments regarding the history behind the Working Group on Benefit-Cost Analysis might be of interest. In August, 1974, a discussion paper covering some topical areas of current interest in benefit-cost analysis was circulated among the departments comprising the membership of the Environment and Land Use Committee. In addition, the Crown Corporations and Commissions received the same correspondence. The Deputy Ministers of these departments and agencies appointed an economist from their staff to be a member of a Working Group on Benefit-Cost Analysis. The broad topic of benefit-cost analysis was divided into a series of sub-topics with each member of the Working Group agreeing to select one or more topics and submit a paper examining that topic in detail. The Committee met again on several occasions and by early 1975 all papers had been submitted. The Chairman's duty was then to edit the papers into a consistent whole. This proved to be a more ambitious exercise than anticipated with the result that the Chairman elected the alternative approach of drafting the Guidelines weaving in the Working Group members' contributions as required. This process also proved more ambitious than anticipated and at times the Guidelines languished due to the interference of other projects. However, in June, 1976, the first full draft was presented to the Working Group.

The Guidelines for Benefit-Cost Analysis is definitely not an instruction manual. It is a reference document for use by analysts who have had a reasonable exposure to economic theory at least at the intermediate university level. It is the opinion of the Chairman, if not the entire Working Group on Benefit-Cost Analysis, that a 'cookbook' style approach to project evaluation can lead only to less than satisfactory results simply due to the fact that benefit-cost analysis is still, to perhaps a considerable extent, an art. While the Guidelines hopefully make some progress toward reducing the area for judgment, it will be clear to the analyst as he refers to the Guidelines that judgment still remains a feature of the proper analytical approach.

With respect to the organization of the Guidelines themselves, the Forward is intended to give politicians and senior civil servants a very quick overview of benefit-cost and policy analysis. Most policy makers will elect to read no further. However, those with a personal curiosity about benefit-cost and policy analysis will find in Chapter 1 a somewhat more technical (but still general) exposition of the foundations of the ideas stated in the Forward. Non-economists will likely read no further than Chapter 1 as Chapters 2-6 contain the detailed Benefit-Cost Guidelines. Chapters 2 through 6 presume a certain familiarity with economics as indicated above and a reading of these chapters might prove frustrating for non-economists.

FOREWORD

Benefit-Cost Analysis and Project Evaluation

The fundamental rationale behind any form of governmental activity in the economy is the improved performance of the economy brought about by such activity. Performance is measured by the degree to which an activity helps society reach its goals. There exist a variety of available governmental policy instruments which may be employed to improve the economy's performance - among them are taxes, subsidies, regulations, and direct provision of goods and/or services by the government. The evaluation of projects which directly provide goods and/or services is the subject dealt with in the Guidelines for Benefit-Cost Analysis.

Within the area of project evaluation we assume that choice is necessary. In other words, government has more opportunities available for improving the performance of the economy than it can possibly undertake with the available resources. Thus, projects or opportunities compete for the limited resources available. Furthermore, part of the cost of undertaking a particular project is the improved performance of the economy associated with other project(s) which cannot be undertaken due to limitations on available resources. In other words, projects are compared one against another so as to determine which advances the economy most substantially toward its goals.

The project evaluation technique applied to analyze the implications of choice among projects is benefit-cost analysis. Benefit-cost analysis as a recognizable body of partly standard and partly developing methods has grown out of an interest on the part of certain economists in applying their expertise to the solution of the choice problem facing governments. The type of benefit-cost analysis conducted in the evaluation of public sector projects is distinguished from its private sector counterpart by several features:

- The adoption of a broader frame of reference;
- The liberal use of the concept of sacrifice cost or opportunity cost. In value terms, opportunity cost is what must be given up (sacrificed) to gain something else of value. Sacrifice is viewed from the point of view of society, the most commonly used referent group, hence the term 'social' opportunity cost.

Sometimes the term social benefit-cost analysis is used to make this distinction clearer.

Analysts performing benefit-cost analyses normally take for granted the existence of a variety of governmental objectives which can be categorized as follows (there is no priority ranking implied):

(a) economic growth;

(b) social well-being;

(c) natural environmental quality.

In addition, there is typically a diffuse, but nevertheless important concern, for achieving a fair and equitable income distribution. Thus, a fourth objective is added to reflect this concern:

(d) income distribution/regional development.

Stating the standards by which performance of the economy will be measured (i.e., stating objectives) is an important first step. But before analysis of any particular projects can proceed, it is necessary to define what is referred to as the referent group. This is simply the group for which changes in economic circumstances caused by the project(s) are considered important. Any project effects occurring to non-members of the referent group are ignored. Typically, the referent group will be coincident with the political jurisdiction of the government doing the project analysis, although valid circumstances may give rise to both smaller and larger referent groups.

The merit of any government policy can be judged according to the degree to which it advances society towards its stated objectives. In evaluating projects, each specific opportunity is analyzed according to the technical economic principles of benefit-cost analysis and is ranked relative to its competitors based on the degree to which each suceeds in meeting the array of objectives. The ranking based on this analysis (technically referred to as 'economic efficiency') is generalized in that benefits and costs are attributed to the project no matter to whom they accrue, provided that the individual or group is a member of the referent group defined at the inception of the analysis. However, in the array of objectives set out above, we noted that specific groups of individuals may be of particular interest to society for a variety of reasons. For example, government may have the general policy of aiding farmers. Therefore, in carrying out its activities and policies, government will want to insure that other groups do not enjoy gain at the expense of farmers. Analysis carried out under this fourth objective is referred to by economists as 'distributive analysis' for obvious reasons.

At the risk of oversimplifying the foregoing discussion of the purpose and process of project evaluation, benefit-cost analysis produces answers to the two questions:

(i) How large an increase in the size of the pie is produced by each of a number of projects; i.e., what are the contributions to economic efficiency?

(ii) Who gets what size of piece; i.e., what effect has the project on income distribution?

Summary

Project evaluation is an analytical and decision process which helps to illuminate the implications of choice among alternatives. It consists of technical analysis and political judgment. Therefore, project evaluation is a process which combines the work of analysts, politicians and senior public officials to achieve improved decisions. The technical analysis highlights

- -- the degree to which a project contributes to the objective of economic growth;
- -- the opportunities for mitigation of possibly adverse environmental and/or social effects of the project;
- -- the income distribution effects of the project.

Political judgment is required

- -- to make final decisions on project choice through use of technical information;
- -- to determine whether sufficiently adverse income distributional effects have occurred and to activate corrective measures if desired;
- -- to pass judgment on mitigation expenditures which exceed the value of the resources sacrificed.

The increasing presence of government in economic affairs through government's several policy instruments (e.g., taxes, subsidies, legislative regulations and public enterprise) must be justified on the basis of the improved performance of the economy resulting from this activity. Properly conducted project evaluations through application of benefit-cost techniques are one means of insuring that economic performance is improved.

CHAPTER 1

BENEFIT-COST AND POLICY ANALYSIS

1.0 Introduction

The purpose of this introductory chapter is to set the methodological stage for our subsequent discussion of detailed benefit-cost principles and guidelines. The intent is to explore the basis for the functioning of economic analysis in public-sector decision-making, to interpret the broad objectives of governmental economic policy in analytical terms as seen by the economist and to indicate how a particular technique of public sector decision-making - benefit-cost analysis - fits into this broad policy framework.

This chapter begins with a necessarily broad scope. Almost any governmental action has economic ramifications and could be analyzed in terms of economics. Therefore, economic analysis of public policy is potentially a very wide field of inquiry. The importance of benefit-cost analysis as a tool of public policy analysis is briefly described in the first section. Then the role which the economist may play in the area of public policy analysis is developed. In Section 1.2, the economist's view of the goals of public policy is interpreted. This interpretation is followed by a description of how the social accounting system aids in measuring advances toward or movements away from the goals.

Section 1.4 describes how the market system assists society in achieving its goals. However, we find that the market does not always work well; when it fails, society fails to achieve its full potential. This short fall of social potential is the signal for policy intervention to "patch up" the market mechanism. Subsequent governmental actions may be classified into two categories - establishment of constraints on private decision-making, i.e., regulation; or substitution of governmental for private decision-making. The latter is our primary interest.

Having established this central interest, it is recognized that the efficiency goal must be bolstered by analysis of the effects of a project on the income distribution to take account of the equity objective.[1] Finally, the logical framework of benefit-cost analysis is developed and it is indicated how this technique can select from among several alternatives, those which advance society most substantially towards its goal(s).

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[1] The development of the full multiple-objective project evaluation framework is found in Chapter 6, Section 6.3.

Throughout, some attention is devoted to describing the limitations of benefit-cost analysis as well as its strengths. The purpose in highlighting these limitations is that, hopefully, decision-makers and analysts will recall these and keep the quantitative aspects of benefit-cost analysis in perspective with other, difficult-to-quantify decision criteria of interest to society.

1.1 Benefit-Cost and Policy Analysis

Benefit-cost analysis is a technique for comparing alternative investment opportunities. It provides for the logically consistent organization of information in such a fashion that decision-making is facilitated. As shall be shown, benefit-cost analysis has its roots in economics and it should therefore not be surprising that a substantial portion of the basis for comparison is economic in nature.

Two ideas which follow from the above paragraph and which warrant development are:

(i) benefit-cost analysis is technique which compares alternatives;

(ii) the broadened and broadening scope of benefit-cost analysis as viewed by the economist.

Taking (i) first, it is important to recognize that the demonstration that a particular project is socially profitable on the basis of some criterion is necessary for the project to receive approval. But it does not indicate that the project is more profitable than some other project or that it is the least-cost means of achieving the given objectives. This raises the issue of the relevant range of alternatives. These topics are dealt with in Sections 1.7 and 5.2.

As a result of the involvement of economists in the development and application of benefit-cost analysis, the scope of the technique is now broader in several respects. It is broader in the sense described in (i) as well as in the types of programs to which it is applied. Historically, benefit-cost analysis was applied largely to the evaluation of projects involving physical structures. More recently the same techniques have been applied to health and human resource programs in the public sector. Finally, benefit-cost analysis is broader in the sense that it requires more than the 'engineering economics' approach to which it was traditionally put.

1.2 The Role of Economics in Public Policy Formation

The economist's role in public policy formation and evaluation has been referred to as that of 'social engineer'. The analogy is instructive but should not be carried too far. In a democratic form of government, the economist plays the role of advisor in public policy matters. In this advising role, he may perform two functions:

1. Given an objective or set of objectives, the economist possesses the expertise to suggest and evaluate the effectiveness of the alternative methods of achieving that objective. On the basis of such analysis, the economist may in certain circumstances, recommend one of the alternatives as the best means of achieving the objective(s). One of two conditions must exist in order for the economist to make such a recommendation.

   a) There must be no income distributional effects attendant on the policy change. By this is meant that there must be no changes in the proportion of society's total income received by any one group of individuals which is caused by the policy change; or,

   b) If there are such changes as in a) above, the economist may still recommend a best policy if he is given information as to the society's desired income distribution.

   However, in most instances, changes in governmental economic policy involve changes in income distribution and since the politician is unlikely to inform the economist precisely as to the society's desired income distribution, final decisions as to the course of action to be adopted must rest with the politician. However, the economist can analyze the pre- and post-project income distributions and thus indicate the income distributional impact of the project(s).

2. Alternatively, given a policy decision, the economist possesses an analytical framework capable of examining the impacts of that policy on a particular policy objective or the whole array of policy objectives which society adopts. It is assumed here that the policy maker has suggested the form alternatives are to take and selects those to be subject to further analysis.

Not all economists concerned with public policy formulation would so readily accept this characterization of their role. It has been suggested that there are practical reasons for a broader working framework for economists. To quote one of the primary exponents of this view, "allowing that the economist is both competent and honest, and produces a detailed list of all the 'economic' implications of each of the several policies under consideration, it is sure to baffle the ordinary politician. The economist can confidently anticipate a request that he, the economist, somehow 'organise' the raw data; that he provide some method by which the large variety of consequences expected from each policy be weighted in some way so as to enable the politician to compare the overall merits of the alternative policies."[1]

The crucial point of contention hinges on the phrase ".... consequences from each policy be weighted in some way....". For consequences which flow through the market place there is a weight which may be attached, i.e., the market price. For consequences which do not enter a market (the classical example is pollution), no market price exists. In addition, both marketed and non-marketed consequences may affect the relative distribution of income among individuals in society. If these income distributional changes are not to be accepted with equanimity, weights must be attached to the one dollar of income 'taken' from one individual and 'given' to another. Finding methods of putting a price on non-marketed consequences is a matter of technique and work is under way in the economics profession toward filling the presently existing gaps. However, putting weights upon the value of changes in the relative income distribution is not, as suggested above, a matter of technique but one of social philosophy over which the economist possesses no expertise or control beyond that of any other citizen. Thus, the more confined role of economics in policy formation is preferred. The evaluation principles and guidelines which follow are based upon this view of the role of economics.

Even within this confined role, our view is that economics has much to contribute to policy analysis and to the process of enhancement of social well-being. This does not require the economist to be concerned with society's ethics. Rather, he attempts to do value free analysis, leaving an interpretation of society's ethics to political decision-makers.

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[1] Mishan, E.J., Cost-Benefit Analysis: An Informal Introduction. London: Allen and Unwin, 1971

1.3 The Social Accounting Framework

1.3.1 The Pareto Criterion

The economics of the public sector operates on the general presumption that the ultimate aim of public policy is the maximization of social well-being. This general policy goal as stated is extremely vague and must be specified more precisely before it can have any operational meaning. Economists have devised the concept of a social welfare function which is simply a formalization of the factors which are thought to be important in describing the level of social well-being and changes in the level. In attempting to specify more precisely the components of the social welfare function, the economist encounters a fundamental difficulty. There is no clear social consensus as to what constitutes social well-being or social welfare and hence as to what elements should enter into the determination of public policy. Economic theory is of little help in solving this dilemma. The approach adopted by welfare economics[1] is to avoid this impasse and specify a fundamental proposition which is likely to receive social consensus. This proposition is called the Pareto Criterion (after the 19th Century economist who first stated it). The Pareto Criterion holds that a situation A is superior to a situation B if in A each member of society is at least as well off as he was in B and at least one member is better off in A than in B. Thus, without specifying precisely what constitutes social welfare, it is now possible by this criterion to identify various social orderings as superior or inferior. The Pareto Criterion is the heart of welfare economics and consequently is central to the economics of public policy.

But the Pareto Criterion does not include concern for the initial distribution of income. It applies as well to one initial distribution of income as to another. Thus, consider an economy in which 10% of the people receive 90% of the income. This economy can, by applying the Pareto Criterion, identify one policy as being superior to another if everyone is at least as well off with a particular policy and one individual is better off than with its alternative(s). On the other hand, an economy in which income is more evenly distributed, with 10% of the people receiving 10% of the income, 20% of the people receiving 20% of the income, and so on, can just as usefully apply the Pareto Criterion.

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[1] Welfare economics is that branch of economic inquiry which concerns itself with the conditions under which the economy achieves its maximum potential as measured by the variables and parameters of the social welfare function. Traditionally, per capita consumption and the degree of equality of the income distribution have been thought to be of great importance. More recently, other factors would be added to the social welfare function.

Since the Pareto Criterion deals solely with economic efficiency, the formal structure of welfare economics cannot incorporate income distributional effects. Yet if the society is concerned with its income distribution, it is quite possible for social welfare to be enhanced simply by a redistribution. Therefore, for a society concerned about being 'better off' in the efficiency (Paretian sense) and also concerned about the distribution of income, the Pareto Criterion yields an incomplete decision-making rule. Ways and means must be found to shore up the Pareto Criterion since frequently, changes in the income distribution are an important, if not the most important aspect of public policy.[1] Regional development programs provide a contemporary example. The presumption is that by government actions, incentives may be created producing a stimulus to development in a particular region, thereby bringing about a relative change in the income distribution. Alternatively, development may be explicitly rechanneled from one region to another, again, with the same presumed effect. Without becoming involved in a discussion of the difficulties of measuring the resulting income changes, it is quite clear that the Pareto Criterion will not provide a full measure of the effects of these actions without some subsidiary rule defining the relationship between incomes in each of the two regions.

1.3.2 The Compensation Principle

To further operationalize the Pareto Criterion, economists have applied the following reasoning. Any public action, say an investment project, may have both desirable and undesirable effects on individual members of society. Those who gain from the project receive a net benefit which may be represented in money terms by the maximum amount they would be willing to pay to have the project go forward. Those who lose by the project suffer a cost which may be represented by the minimum compensation[2] they would require to make them indifferent if the project were to proceed.[1] Allowing ourselves the momentary luxury of assuming that the society is capable of making transfers of income among its individuals in a cost-less manner, the Pareto Criterion may be generalized into the Compensation Principle which underlies all benefit-cost analysis. The Principle holds that a policy should be implemented if and only if the individuals who gain by the policy can fully compensate (via notional income transfers) the individuals who lose as a result of the policy and still have some excess net gain remaining. This criterion also holds that the notional transfers do not actually have to be made in order to establish the superiority of situation A over B.[2]

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[1] This point is taken up again in the discussion of compensation in chapter 6. There, an operational method of incorporating income distributional considerations in the 'social welfare function' is developed.

[2] Compensation in this context is not to be confused with the more general lay definition of compensation, meaning simply a payment or remuneration. Here, compensation means a specific 'notional' payment whose amount is given by the equivalent or compensating variation whichever is appropriate in the circumstances.

1.3.3 Units of Measurement

While we now possess a criterion by which public policies may be ranked according to their social profitability, we still require units of measure and a framework for measurement of social profitability. As an extension of the proposition that the end of all economic activity is consumption, we measure the social profitability of policies in terms of additional consumption opportunities they provide which would not be available if the policy were not implemented. Consumption is broadly defined to include both consumption of goods and of services. According to this definition, white-water canoeing qualifies just as much as does devouring a thick, juicy steak or dropping a quarter in the local bus fare box. These additional consumption opportunities are measured in dollar terms, of course, and in the context of the social accounting system are normally viewed as 'benefits'. These additional consumption opportunities are sometimes referred to as 'efficiency effects' or 'allocative effects' which connotes the impression that the economy has improved its productive capability such that more consumption may now be obtained than could be had in the absence of the policy. Care must be exercised in the determination of the efficiency effects of a policy decision for it is easy to confuse these effects with distributive effects, i.e., changes in the distribution of income (consumption).

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[1] There is a rather complex technical issue involved here to which we refer but will not develop. The issue involves the appropriate measure of loss of the 'victim' of a project and the non-neutrality of legal liability on the evaluation of adverse impacts of a project. The result has been stated: proper evaluation requires comparison of 'compensating variations' irrespective of the type of law actually operative. Compensating variation is that value which leaves the 'victim' as well off with the project as he would have been without it. For a full discussion of this issue the reader is referred to E.J. Mishan, Cost-Benefit Analysis, Chapters 18-21.

[2] It has been shown that this 'Kaldor-Hicks Criterion' is not always internally consistent. In spite of this problem, benefit-cost analyses proceed, presumably on the assumption that one can conduct the analysis as if the efficiency-distribution dichotomy was valid. We adopt this convention but explicitly incorporate distributional considerations. See Chapter 6 for detail.

1.4 The Market System and Public Policy

1.4.1 The Properly Functioning Market

Under normal circumstances society relies on the private market system to provide the broad array of goods and services we wish to consume. The relative social value of these goods and services is defined by the process of purchase and sale in the market place if the market is working properly. A properly functioning market is defined by a variety of technical conditions relating to the number of buyers and sellers in a market (there should be 'many'), the degree of effect over price of any of the buyers or sellers (there should be none) and the adequacy of the market participants' information (it should be perfect). In some instances, markets approximate these conditions sufficiently well such that no cause for interruption is found. However, in other instances this is not the case with the result that the social and private value of goods or services will diverge. This divergence establishes the basis for market intervention in the form of public sector economic policy. This policy may take the form of public provision of goods and services or laws and regulations which govern the private production and marketing of goods and services. The divergence between private and social values may occur under two additional sets of circumstances. Some goods or services, due to their intrinsic character, do not lend themselves to private production because they cannot be packaged and sold separately to individuals whose consumption of the good or service reduces the total amount available for consumption. These goods and services are variously referred to as 'non-exclusive', 'collective consumption' or 'public' goods. Classic examples of this type of good or service are lighthouses, national defense, administration of justice, etc. These goods and services must be collectively produced by governmental organizations.

Finally, market failure can result simply from the physical interrelatedness of the economy as it carries out its production and consumption activities. These processes of production and consumption frequently produce 'goods' or 'bads' which are not accounted for and are not internalized as costs or benefits by those who cause their production. The public awareness of the pervasiveness of this market failure is so acute that to amplify this idea is to belabor the obvious. Nevertheless, an example might be useful. Consider airline companies who are not required to pay the individuals who live in the proximity of the airport a price for the disturbance airplanes cause. Due to this, airlines' costs of production are (artificially) lower than they 'should' be; consequently, as a society, we consume 'too much' air travel (assuming an increase in airline ticket prices would cause a decline in consumption of air travel). Presumably a reordering of decision factors which forced airlines to recognize and pay for the 'bads' they produce would cause a new balance to be struck with less airport noise, less air travel and more contented residents.

In the cases of goods and services for which private and social costs diverge due to inadequacies or shortcomings in the market system, as described above, economics is in principle capable of discovering methods of measuring the benefits and costs involved and combining them into a framework useful for policy decision-making.

1.4.2 Non-Market Activities

As we have seen, the market sometimes provides approximately correct relative monetary values for goods and services of a particular type. With occasional necessary adjustments, these values may be used directly in a benefit-cost study. For non-marketed goods and services (or 'bads' and 'disservices') things are not quite so simple. To return to the earlier airline example, in order to evaluate the decision as to whether an airport expansion is warranted, it is necessary to know the 'cost' of increased noise and air pollution inflicted on the local residents in addition to construction costs and service value provided by the expanded facility. The added pollution is definitely tangible to the victims, yet the associated cost is not reflected in a market price.

Correspondingly, when the government makes a decision to create an ecological reserve, it must know the value of all the activities the reserve will support. Many of these activities may be notional; for example, the value a person derives from retaining the option to visit the reserve even though he has not visited it in the past. Clearly, these values are difficult to measure but they are not in principle impossible to measure. As shall be shown in the following chapter, activities whose value was considered immeasurable only a few years ago are now capable of acceptable approximation by several methods.

There are two points of importance here and we shall state them for emphasis.

i) The terms tangible and intangible have no meaning with reference to the quantifiability in principle of the value of activities. Everything of worth has an economic value which is measurable at least conceptually.

ii) That it is so difficult as to be impossible to measure the value of some activities does not signal a failure of benefit-cost analysis. Rather, the shortcomings lie in our present measurement methods which are subject to development. The logical framework of benefit-cost analysis is fully capable of including all values whether marketed or non-marketed.

1.5 The Distribution of Income

1.5.1 Current Distribution Versus Distribution Over Time

The basis for society's concern for income distribution may be developed in the following way. It is assumed that society's ultimate objective is a high standard of living (maximum social welfare). The standard of living is provided through consumption of goods and services (consumption is the end of all economic activity). A first approximation measure of the standard of living is per capita consumption. Since consumption occurs through time, consumption now and consumption next year are competitive. Since any span of time may be divided into many periods, consumption per capita in each of these periods is competitive with consumption per capita in all future periods. By its policies, government may increase one or more of the levels of consumption per capita in any time period but only at the expense of reducing the level of consumption per capita in one or more other periods. But if consumption per capita is steadily rising through time, people in the future will have a higher standard of living. Following this reasoning, there need be less concern on the part of government for raising future levels of consumption per capita than in raising current levels of consumption per captia.

If the consumption per capita to be enjoyed by future members of the society is given less importance due to the fact that they are generally better off (per capita consumption is rising on a trend line), then logically it must be true that the consumption of the worse-off individuals of comtemporary society must be of greater importance than that of the better-off members.[1]

A method of reflecting the relative importance of the present and future generation's income is to discount the income received by future generations. Thus, in evaluating projects or decisions which have effects on future incomes, future income is reduced by a factor which becomes larger as the futurity of incomes becomes greater. The rate used to calculate this factor has appropriately been termed the social rate of discount. Considerably more discussion on this issue will be found in Chapter 4.

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[1] Little, I.M.D. and James A. Mirrlees, Manual of Industrial Project Analysis in Developing Countries, Volume II, Social Cost-Benefit Analysis, OECD, Paris, 1969. Little and Mirrlees develop this idea more formally.

1.5.2 Equity and Efficiency

It was indicated in a previous section that the Compensation Principle yielded no information concerning the distributional impacts of public policy decisions. If society is not indifferent to the distribution of income the Compensation Principle cannot be used alone as a social investment criterion. It must be supplemented by reference to and analysis of the distributional ramifications of decisions. Thus, it is possible that a project which satisfies the Compensation Principle may be socially undesirable due to adverse effects on the income distribution. Conversely, a project may be socially desirable if it has beneficial effects on the income distribution even though it fails the Compensation Principle test.

This brings us back to the question of the proper function of economic analysis of public policy. It is impossible for the economist to resolve this dilemma unless he receives instructions from society (through elected representatives) as to the relative importance it places on the consumption of different income classes. Only in the very rare coincidental instance in which two or more alternative policies have the same impacts on the income distribution, will it be possible for the economist to make a policy recommendation without further information on the desired income distribution.

Thus, we arrive at the conclusion that policy decisions based on the Compensation Principle will be conditional on a review and decision concerning the effects of the policy on the income distribution. This of course implies that information on the distributional effects of policies will be obtained and that it can be put into a format which will facilitate decision-making. Methods for performing this task will be discussed in Chapter 6.

Before leaving this topic, one final important thought is in order. If policies are judged solely on the basis of distributive criteria, the result may be that a number of socially profitable policies (judged on the basis of the Compensation Principle) are not carried out. The result is a sacrifice of potential real income. Since other methods of adjusting the distribution of income are available, it may be well to start with the goal of developing an efficient resource allocation system.

1.6 Benefit-Cost and Policy Analysis Again

As has been seen, through a public investment program, the government is able to affect society's consumption per capita. In addition, the distribution of consumption among different classes of individuals may also be affected by the government's investment program. This may result from the type of project which the government selects (capital or labor intensive) or the placement of the project within one region as opposed to some other. Benefit-cost analysis is the analytical framework employed to determine whether projects or policies are in society's interests as determined by the Compensation Principle. It is an application of the welfare economic framework described above.

Benefit-cost analysis is not a new technique and was not originated by economists. Economists have become interested within the past twenty to twenty-five years as interest in public investment decision criteria has grown. A rather vast and growing body of theoretical and applied literature is evidence of this interest. As a result of this involvement, the technique is markedly different from its previous character. It continues to evolve. Historically, benefit-cost analysis exemplified a narrower focus centering mainly on project justification. To economists, benefit-cost analysis is much broader in scope, having its groundings in welfare economics as has been described above. In this document, the term benefit-cost analysis carries the broader connotation. Appropriately, it is sometimes referred to as social benefit-cost analysis.

1.7 The Analytical Procedure

As it has been recast by economists, benefit-cost analysis is a comparative technique. This view of the technique is of utmost importance and it cannot be stressed enough. The excess of social benefits over social costs or a benefit-cost ratio greater than 1.0 is a necessary but not sufficient condition for projects to pass the efficiency test. The above conditions define a socially profitable project but do not insure that the project represents the least cost means of achieving the stated objectives. This latter condition can be met only by a thorough review and comparison of alternatives.

In a decentralised decision-making structure such as we have in the Province of British Columbia, each department or agency receives a budget allocation. These funds represent the maximum amount which may be expended by the department and therefore represent a constraint on the size of project or projects which may be undertaken.

The department may be searching for the 'best' way to achieve a goal which is set by statute, agreement, regulation or accepted policy.

Benefit-cost studies should contain assurances that other alternatives to the project lie beyond the limits of such statute or policy. The implication of these comments is that a benefit-cost study should begin with a description of the purposes and anticipated benefits of the project as well as a documented description of the constraints on the department beyond which better alternatives may not be sought.[1]

Thus, for most departments or agencies, the task of making a good benefit-cost analysis is one of determining the correct range of alternatives and comparing them. It is not concerned merely with converting a technical or scientific feasibility report on a project into benefit-cost jargon but with looking beyond such reports so as to ensure that all relevant alternatives do not yield a better course of action. The onus for creating the atmosphere in which this type of search may take place must fall upon the decision-maker. Frequently, the benefit-cost stage of departmental analysis should result in the commissioning of technical studies of other alternatives, (or in conferring with other branches, departments and levels of government) about alternative ways of spending the same budget, achieving the same purpose or even constructing the same type of project.

The consideration of a broad range of alternatives should result simply from the structure of the Environment and Land Use Committee. This is a vehicle which is designed specifically for the consideration of problems in an extra-departmental context. The employment of this forum can go a long way towards focusing decision-makers' attention on the important issues.

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[1] Stemming from work done by A.D. Scott and W.R.D. Sewell on the use of benefit-cost analysis in Canadian Federal Government agencies.

CHAPTER 2

EVALUATION OF THE STANDARD PROJECT

2.1 Introduction

This chapter contains a portion of the detailed evaluation principles and guidelines proposed for adoption and use by the Environment and Land Use Committee.

Chapter 2 begins with a consideration of the procedures for evaluating what is defined as the 'standard project'. We first define the standard project and then develop the principles and guidelines associated with evaluating the social benefits and costs of a project meeting this definition. There follow sections in which we continuously relax the assumptions used to define the standard project and show how relaxing the assumptions affects the evaluation principles and guidelines. This procedure is carried out first for the benefit side and secondly for the cost side.

2.2 Evaluation of the Standard Project

2.2.1 Definition of the Standard Project

This section is devoted to a presentation of the principles involved in the evaluation of what shall be referred to as the standard project. The standard project is defined by a series of assumptions which are set out below. These assumptions may appear as rather confining at first blush. Nevertheless, constraining the field of view for the present time will prove to be beneficial in highlighting the fundamental principles involved in project evaluation. Having once developed these principles and measurement procedures, we will then proceed to drop the assumptions and extend the analysis so as to deal with more difficult, albeit more 'realistic' situations.

The standard project is defined as one which exhibits the following characteristics.

i. There exists a single objective (i.e., added consumption opportunities with consumption being viewed in a broad context as described in Chapter 1).

> All benefits and costs of the standard project are defined in relation to this objective. For present discussion of the standard project, we assume that the distribution of the added consumption opportunities among regions or individuals may be handled by means other than project selection.[1]

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[1] The economist's concern for 'non-efficiency' objectives will be discussed in a later chapter. The implication of assumption i. is that allocation effects and distributional effects of a policy may be analyzed separately. Generally, projects are evaluated by viewing the state of the economy 'with' and 'without' the project. This procedure is based on the assumption that market prices are an adequate reflection of the social value of the outputs generated and the inputs consumed by the project. Market prices are, however, dependent upon the initial (pre-project) distribution of income. If the initial income distribution is not 'correct' (i.e., the one desired by society) then the resultant market prices are not 'correct'. Some economists would therefore conclude that market values may be inappropriate measures of social value since a different ('more equitable') income distribution would result in a different set of market clearing prices. While it is acknowledged that this is the case, our position for the moment is that this is not a problem of the analytical structure of benefit-cost analysis nor of the adoption of the allocative criterion, but of the market system itself. If income distribution is a concern to be included in project selection, it is the distributional impact of the project itself which must be measured and ascribed to the project. For this purpose, the pre-project income distribution may be accepted as given. Thus, if some individuals or groups of individuals are thought to be more deserving than others, the relative deservingness of these groups should be made explicit prior to the project analysis and decision-making. On the problem of a strictly distributional goal see page 10 of Chapter 1. Additionally, there is evidence indicating that some types of public projects do in fact redistribute income to low income individuals.[2]

[2] Haveman, R.H. and J.V. Krutilla, Unemployment, Idle Capacity, and the Evaluation of Public Expenditures: National and Regional Analysis. Johns Hopkins Press, Baltimore, Maryland, 1968, p. 89.

ii. All benefits and costs of the project are quantifiable in commensurate dollar terms.

iii. The economy is fully employed.

iv. The price of each factor of production is regarded as an adequate reflection of the marginal social value of the factor.

v. There are no spillover effects of the projects.

vi. The projects under evaluation are not mutually exclusive in the physical sense. An example of two mutually exclusive projects would be the construction of a natural gas pipeline having a variety of possible diameters. Each is a different project, yet only one may be installed. The analytical problem in this situation is two-fold - whether a pipeline should be laid or not and if so what should be the appropriate size. This is a matter quite different from that of e.g., selecting the appropriate means for developing a region or river basin.

vii. The projects are not interdependent in the physical or economic sense. This means that the projects to be evaluated are separate entities and that there are no price or cost interdependencies nor any factors of production which would be used in one as well as the other project.

viii. The method of financing the project has no impact on its relative desirability.

2.2.2 Identification of the Referent Group

In spite of the arbitrariness with which political jurisdictions are drawn, for purposes of implementing the allocative rule (Pareto Criterion) the appropriate referent group is the political jurisdiction of the relevant decision-making body. In the benefit-cost literature this is normally assumed to be the national political forum. Thus, any individual within the boundaries of this jurisdiction who receives gain or suffers loss as the result of a project would have such benefit or cost included in the project evaluation. Although universalists may not be in agreement with this approach, concern is normally not voiced for extra-frontier project impacts, beneficial or adverse.

In the regional (provincial) context of concern to the B.C. Government, the appropriate referent group is the provincial populace. Bringing the national analogy down to the regional level in this manner will not likely cause much mischief. There may, however, be projects in which extra-provincial project impacts should be recognized. Such projects will likely be obvious and identifiable by their scope and/or location and may provide opportunities for co-operative ventures.

Sub-provincial referent group definitions may be of interest for purposes of regional development schemes. Within the assumptions defining the standard project (esp., the single objective assumption), sub-provincial referent group definitions may be implemented only by precise specification by political decision-makers of the relative worth of additional income in the two (or more) regions. Granted, this is a rather demanding requirement but, in the context of the Pareto criterion, is the only means of evaluating a sub-provincial development scheme.[1]

Therefore, several levels of analysis will be required. In the first instance, the analysis should proceed on the basis of the national referent group definition. That is, benefits and costs of the project should be accumulated irrespective of the provincial political jurisdiction in which they occur. Following this, regional analysis may be undertaken in order to accumulate the benefits and costs from the viewpoint of the Province of British Columbia. If the regional income specification condition stated above is met, the project may then be evaluated from the viewpoint of particular regions within the province.

For many public expenditures, this may not be so involved as it appears. The impacts of most projects undertaken by the British Columbia government will likely occur primarily within the borders of the province. Thus, the national and provincial benefits and costs will be equivalent, no separate analysis being required.

In preparing the project appraisal, the analyst may reduce the effort required to prepare this information by breaking down by geographic area the benefit and cost estimates constructed at each stage of the analysis. The various referent group benefit-cost analyses may then be developed simply by bringing together the relevant benefit and cost estimates.

GUIDELINE:

The provincial referent group definition should guide the accumulation of benefit and cost estimates for public projects. However, national and sub-provincial referent group definitions should also be used in the appropriate circumstances as detailed above.

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[1] In Chapter VI the problem of multiple objective benefit-cost analysis is considered.

2.2.3 Accounting for Project Benefits

2.2.3.1 The Benefit Measurement Principle I: Final Goods and Services

The reader should review assumptions i, ii, iv and vi at this time. The benefits of a project are defined as the value of increased output (over and above what would be available without the project) of goods and services which the project makes possible. The appropriate point for measurement of these increased outputs is at the final consumer level (recall the discussion in Chapter 1 regarding the ultimate end of economic activity).

In economics, the value of a good or service is measured by the willingness of an individual to pay for it. The representation of an individual's willingness-to-pay is the familiar demand curve indicating the quantities of a good demanded at differing price levels. In a market, the sum of all individual demand curves for the good or service is the market demand curve. Thus, in benefit-cost analysis, the gross value of increased outputs of goods or services is measured by the willingness to pay on the part of project beneficiaries as a whole for additional units of output.[1] Note that willingness-to-pay presumes the existence of an effective demand for the project output. While it may not always (or even frequently) be possible to estimate this quantity directly, all measurement techniques are designed to obtain an adequate proxy for this value.

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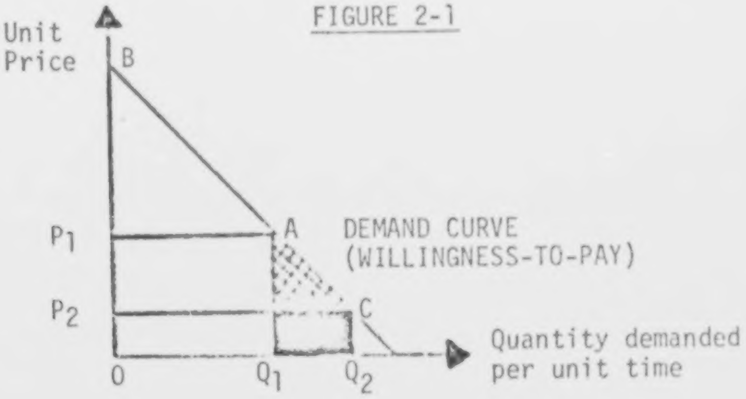
[1] Clarification of some technical points may prove useful at this stage. Alfred Marshall's concept of consumer's surplus was defined such that it contained an implied constraint on the quantity purchased. To Marshall, consumer's surplus was that quantity an individual would be willing to pay over and above what he actually had to pay, rather than go without the good in question. Hicks later recognized that an individual required to pay the full willingness to pay for a good would be unwilling to consume the same quantity as he would consume if he paid the (lower) market price. The income effect of paying (the full consumer's surplus) for the privilege of consuming a good reduces the individual's real income such that he would be unwilling to purchase the same quantity as before having to pay for the privilege. This led Hicks to define the compensating variation and equivalent variation. Compensating variation is that amount an individual would have to pay (or receive, depending upon the circumstances) after the occurrence of an economic event such that he is in the same welfare position as before the event. Equivalent variation is the amount an individual would have to pay (or receive) to leave him in the same welfare position if the economic event in question did not take place. In benefit-cost analysis, compensating variations are the quantities we attempt to measure. For a detailed but lucid explanation of these issues, as well as an explanation of how the area under the demand curve above the price line approximates consumer's surplus (compensating variation), see E.J. Mishan, Cost-Benefit Analysis, pp. 325-338.

Assuming a non-zero price and the usual relationship of quantity demanded to price, willingness-to-pay is measured by the market value (price x quantity purchased) of the additional goods or services produced, plus the consumer's surplus associated with an increment to output. In the form of a diagram, willingness-to-pay may be measured as an area. (See figure 2-1 below.)

The diagram indicates that prior to the installation of the public project in question, quantity Q_1 of the good was demanded at a price P_1. The addition to supply caused by the public project reduces the price to P_2 at which price Q_2 is demanded. The market value of the increased quantity consumed is approximated by the area of the darkened rectangle; that is, P_2 times Q_2 minus Q_1. The change in the total market value of consumption of this product as a result of the supply increase is the area of the rectangle $OP_1\ AQ_1$ minus the area of the rectangle $OP_2\ CQ_2$. The amount of consumer's surplus associated with this increased consumption is equal to the area of the cross-hatched triangle. The total area of the rectangle plus the area of the triangle is the value which a perfectly discriminating monopolist could realize. A perfectly discriminating monopolist is able to charge a different price to each consumer. The value of consumption of the product in this market after the supply increase is the area of the trapezoid $OBCQ_2$. $OP_2\ CQ_2$ is the amount of money changing hands and P_2BC is the value of consumer's surplus derived by consumption of quantity Q_2. Together these areas measure consumer's aggregate willingness-to-pay. Finally, the area of the trapezoid Q_1ACQ_2 is the value attributed to the increased consumption $Q_2\ Q_1$ for purposes of the project in question.

FIGURE 2-1



A good or service not supplied previous to the public project with an estimated demand curve as shown in figure 2-1 and to be sold at price P_1 has a value given by the area of the rectangle $OP_1\ AQ_1$ plus the area of the triangle above this rectangle P_1BA.

For goods and services which are publicly provided free of direct charge, the entire area of the triangle under the demand curve is consumer's surplus and is the gross value of the good or service to be included in a benefit-cost analysis.

GUIDELINE:

Willingness-to-pay is the general gross benefit measurement principle.

2.2.3.2 Measurement of Willingness to Pay in Practice

2.2.3.2.1 Direct Estimation: Final Consumer Goods and Services

The analyst may encounter one of the following situations when attempting to estimate the benefits of a project.

i. The demand curve for the project output is known or roughly determinable through standard demand curve estimation methods.

ii. The market demand curve is not known and cannot be directly determined by any presently available method.

For situations in which the demand curve is known or can be determined, willingness-to-pay may be estimated directly from the demand curve. Having estimated willingness-to-pay, the analyst is able to make an estimate of the potential decline in market price of the good or service resulting from the addition in supply caused by the new project. If the price decline is expected to be small, the pre-project market price may be used to evaluate the project's benefits. In this case, there will be little additional consumer's surplus. On the other hand, if market price is expected to decline significantly, the price to be used for valuation purposes is that price approximately midway between the pre- and post-project market prices. This price will serve as an adequate proxy for measurement of the willingness-to-pay for the additional units of output. Clearly, direct estimation of the demand curve in the above fashion is most likely to be successful in evaluation of final consumer goods and services.

Where a market determined demand curve does not exist or cannot be estimated directly from market information, special methods may be applied to indirectly estimate willingness to pay. For some types of non-marketed activities, acceptable methods of indirect demand curve estimation are available while, for others, no presently known methods exist. The valuation of non-marketed activities is discussed in greater detail in Section 2.2.6.1.2.

In British Columbia, cases will arise in which the price of a good or service supplied by a public or quasi-public organization is available but it cannot be said to be a competitive or market determined price which adjusts to market supply and demand factors. In the planning period for this type of organization, capacity is normally adjusted to meet some projected future level of demand or demand growth at the present price level and structure. Additions to capacity are likely to have no effect on the price of the good or service no matter how large the additional capacity is in relation to the capacity in place. The unit value of the good or service should be measured by the supply price for the good or service. The gross value for benefit-cost analysis is approximated by the product of the supply price and the number of units forecast to be consumed in each future time period.[1]

The consequence of non-equilibrium prices is the occurrence of excess demand or excess supply. This detracts from the social value of the product or service; accordingly, the cost of congestion in the former case or idle capacity in the latter must be accounted for in the project evaluation. We shall have more to say on this subject at a later stage, particularly when we discuss the interconnection between pricing and evaluation.

GUIDELINE:

Where information and data allow, the value of final consumer goods or services should be measured by the market value plus consumer's surplus for a market priced good. For goods or services not subject to purchase and sale in a market, some means of imputing a willingness-to-pay is required. The methods of imputation are considered in section 2.2.6.1.2.

2.2.3.3 The Benefit Measurement Principle II: Economic Rent

Economic rent generated by the construction and operation of a project should be included among the benefits of the project. The precise meaning of the term economic rent will become clear as we discuss the two instances in which economic rent is generated. These two are distinguished from a third case often mistakenly thought to be included in the economic rent concept.

Given the supply curve of a factor of production, it is assumed that that it is upward sloping with respect to price; i.e., the factor requires a higher payment for more of it to be employed in a particular use. The area above this curve and below the price line (see figure 2-2) may be taken as a measure of the economic rent earned by the inframarginal units of the factor. In figure 2-2, S is the supply curve of the factor and P is its supply price. The shaded area between the price line and the supply curve is a value known as economic rent. At all points on the supply curve between the origin, 0 and S (e.g., S_R) the factors are being paid more than the minimum they would be willing to accept and still be employed in this use. Notice how the concept and measure of economic rent is symmetrical with that of consumer's surplus.

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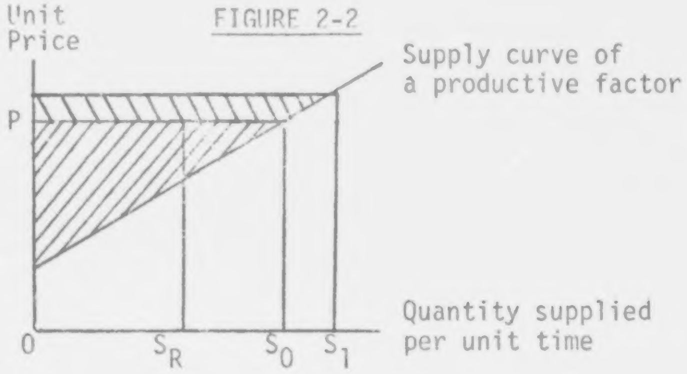
[1] When comparing several alternative means of supplying a homogeneous output, a preferable method is to adopt the 'cost of the next best alternative' as a means of establishing the value of benefits for each alternative. This avoids the problem of non-competitive prices being used to evaluate the output as suggested above. This method is elaborated in Section 2.2.3.4. found on page 23.

An increase in the demand curve for this factor (caused by the project in question) will result in an increase in the economic rent earned by all the inframarginal units. This is shown in Figure 2-2 as a movement to the northeast along the supply curve. The additional rent earned is given by the area of the trapezoid above the original rent triangle. This is the value which would be included as a benefit of a project which led to an increase in demand of S_0 S_1 for this factor.

FIGURE 2-2



In two circumstances, this analysis may be applied to the supply curve of a firm or industry.

i. Ricardian rent: this is the classic case of rent accruing to a fixed factor of production (say, hydroelectric sites) to which is applied variable factors (labor, capital) whose prices remain unchanged. The supply curve for the product of this production process (electricity) rises simply because good sites are limited in supply. As demand for electricity rises, successively poorer quality sites are brought into production. But these poorer quality sites are higher in cost. These higher cost sites determine the margin; meanwhile, the better quality sites earn rent, i.e. receive a payment greater than that required. Reinterpreting figure 2-2, the supply curve now becomes that of electricity with the shaded area interpreted as economic rent accruing to the owners of the fixed factors. Ricardian rent accrues in both the short- and long-term.

ii. Quasi-rent: Productive factors which are fixed in supply in the short-run but whose supply may be augmented in the long-run are capable of earning a quasi-rent due to the short-run fixity of supply of the factor. Thus, capital becomes similar in nature to land and the short-run supply curve for this factor is upward sloping. Reinterpreting figure 2-2, the shaded area is rent earned by a resource fixed in the short-run.

To be distinguished from the above cases of rising industry or firm short-run supply curves is the rise in the long-period industry supply curve caused by the imperfect substitutability of the variable inputs between industries. The result here is a change in the relative prices of the variable factors in different industries. The long period supply curve is a sort of average curve and no welfare significance can be attached to the area above it.[1]

2.2.3.4 Measurement of Economic Rent in Practice

2.2.3.4.1 Direct Estimation: Intermediate Goods and Services

For project outputs which are intermediate goods, the increase in net income of producers who use the project output as an input acts as a proxy measure of the value of that output. As we noted above, such an increase will show up as an increase in the area above the product or service supply curve and below the price line. In like fashion, a public investment which, within a short period, decreases the variable costs of a firm or industry, will generate additional quasi-rents which are also counted as benefits of the project.

It is clear that by recommending the use of net income increase as a benefit measure, we are presuming that either the product supply curve is known (or can be estimated) or knowledge of the pre-project net income of the affected firms is available and the impact of the project on net income can be estimated. Generally, cost or supply curves can be more readily estimated than can demand curves if the information is made available. Firms are normally knowledgable of their cost structure. Whether this cost or net income information will be disclosed to the project analyst is a problem which must be anticipated separately in all project evaluations.

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[1] For a more detailed analysis see E.J. Mishan, Cost-Benefit Analysis, pp. 48-57 or any introductory microeconomics textbook.

Aside from the disclosure problem, use of net income increase as a benefit measure is not without its difficulties as has been indicated by Cicchetti, Davis, et al.[1] Private firms producing a good or service would normally make investments through internally generated funds or through debt financing, these capital funds bearing interest at the market rate (the market rate of interest can be thought of as the opportunity cost of internally generated funds for a private concern). If the public project displaces a private project which would have been undertaken at private initiative, and if private producers do not pay the full market value for the public project output, a subsidy to private producers will have occurred (and their incomes will have increased). Including the increased net incomes as part of the benefits of the project is incorrect in this instance, since the net incomes in fact constitute a redistribution (from the general public to the producers in question). This problem does not invalidate the usefulness of the net income increase as a measure of value added, but it does highlight the need for caution when employing this measure.

GUIDELINE:

Use the net income increase to estimate the economic rent generated by a public project in cases in which it is appropriate, as outlined above.

2.2.3.5 The Benefit Measurement Principle III

Two circumstances may arise in which a third alternative method of gross benefit estimation may be necessary. The two circumstances are:

i. When the output of the public project is a homogeneous good (such as water, electricity), individuals are unconcerned as to its source or the precise production technology employed, and where there are several alternative production technologies available;

ii. If, for some reason (lack of information and/or data), benefit estimation by either of the above two methods is considered infeasible.

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[1] Cicchetti, Charles J., et al., "Benefits or Costs? An Assessment of the Water Resources Council's Proposed Principles and Standards", Department of Geography and Environmental Engineering. Baltimore: The Johns Hopkins University, 1972.

[2] Note that benefit measurement principles I and II are additive if both occur in given circumstances whereas principle III is alternative to both I and II.

In the above circumstances, a final benefit measurement method is to value the benefits of the proposed project at what the most likely alternative method[1] of providing the same good or service would cost the beneficiaries of the proposed public project.

Just as with the net income method, there are problems associated with employing the 'most likely alternative' method.

i. It must somehow be established that society values the project by an amount which is at least as great as the cost of constructing it.

ii. If condition i. is met, the 'most likely alternative' method provides, at best, a minimum estimate of the actual social value of the project.

iii. In some instances it cannot be determined in advance whether the most likely alternative will in fact be carried out if the primary project is not.

For public projects which supply a non-homogeneous product or service, the above problems could be quite serious. However, it appears that one characteristic of publicly provided goods and services is that they are frequently homogeneous, e.g., electricity, urban transportation and so forth. For the homogeneous good case, the 'most likely alternative' method actually turns out to be the correct procedure. The nature of the homogeneous good case renders ii. above non-problematical. Condition i. still requires satisfaction. This focuses attention on demand estimation and forecasting. The satisfaction of condition i. in the case of homogeneous goods implies that iii. will likely not be a problem. One or the other of the alternatives will be put in place. It is likely that this method will see frequent use in public project evaluations in B.C.

2.2.4 Accounting for Project Costs

2.2.4.1 The Principles of Project Costing

The reader should review assumptions ii, iv, v, vi and vii for the remainder of this section. In a fully employed economy, productive resources must be diverted from alternative uses in order to generate the total benefits associated with the proposed project. The value of these productive resources to society is the output value they would have produced if they had remained in their previous use. Thus, the value of these diverted resources which must be ascribed to the proposed project is the sacrifice of output necessitated by the resources having moved to a new employment. Basically, costs are attributable to doing one thing rather than another and stem from the foregone opportunities that have to be sacrificed in doing that one thing. The cost of picking apples can be thought of as the sacrificed amount of peaches that could have been harvested with the same time and effort. The cost of a power project is likewise the sacrifice of doing something else with the same complement of productive resources. This sacrifice of the opportunity to do something else is called, for obvious reasons, 'opportunity cost'. The value of the 'opportunity to do something else' appropriate in reckoning the opportunity cost of resources in one particular use, is, specifically, the sacrificed value inherent in the best alternative resource use.

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[1] Steiner, P.O., "The Roles of Alternative Cost in Project Design and Selection", in Allen V. Kneese and Stephen C. Smith, eds., Water Research (Baltimore: The Johns Hopkins Press, 1966).

Under the conditions established by the standard project assumptions. It may be asserted that the market value of the goods and services used in project construction, operation and maintenance represents the cost to society of generating the project's gross benefits.[1] Specifically, these costs are those of land, labor, capital and management expertise used in construction, operation and maintenance of the facility. Under the assumptions employed in this section these costs are referred to as social costs.

2.2.4.2 Measurement of Project Costs in Practice

The social costs of a project are of two types:

i. Outlays for labor, materials, capital and management expertise.

ii. The net value of foregone opportunities associated with committing land and related resources to one use as opposed to some other.

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[1] A full appreciation of the correctness of this assertion requires some knowledge of the economics of the individual economic agents in society (consumers, producers, government) and how they are interlocked through the general equilibrium of the economic system. A full development of this theory is far beyond the scope of this document. A good text in intermediate microeconomics will suffice to provide the necessary background for the interested reader.

In the simplified world in which we are presently dealing, market prices of inputs approximate their social costs. For the first type, wage rates for labor of each type employed and the actual material costs should be used in building up the cost estimates. The cost of capital is represented by its opportunity cost, i.e., what it could earn in alternative employments. Again, in the simplified economy we're dealing with, a market rate of interest is an appropriate measure of the cost of capital (recall that we are assuming that the method of financing the project has no impact on its acceptability). Chapter 4 deals with a determination of the appropriate rate of discount for projects in British Columbia.

The type ii. project cost is more subtle and more difficult to evaluate. Some resources have the capability of yielding a service flow over time in one of a variety of different forms. A given parcel of land can support forests, agriculture, recreation or housing. In many cases it may be possible for land to support a variety of such activities in tandem. But when taking a decision as to whether to 'dedicate', say, currently forested land to agriculture, the net service flow the land would generate in its present forested state must be reckoned as a cost of conversion to agriculture. This is plain enough. The difficulty lies in the fact that there are always a variety of options available with respect to the use of any resource. This being the case, it is necessary to evaluate the various combinations of resource uses. While this is not conceptually difficult, it does require a certain amount of information and computation. Nevertheless, to properly reckon the full social costs and benefits of a policy action and to be certain that a given action is socially most profitable, this procedure must be followed.

GUIDELINE:

The opportunity costs of resources used to produce the project output are measured by their market values. For labor and materials, actual cost is used. For capital, a market rate of interest approximates its opportunity cost sufficiently well. For commitment of land to a particular use, the value of the service flow from its next best alternative use represents its opportunity cost. Note: the term land is used broadly to include all resources appurtenant to it as well as the surface and sub-surface area.

2.2.5 Summary of the Foregoing

The previous discussion of benefit and cost evaluation may be summarized more formally in the following manner.

When the goal is to maximize the net benefits of a public investment (or alternatively to maximize the efficiency of a public investment), it is important to account all opportunity costs in all sectors of the relevant economy. The objective function then has the following form:[1]

$$Y_{1,2} = \left\{(B - C)_1 - (B_a - C_a)_1\right\} - \left\{(B - C)_2 - (B_a - C_a)_2\right\} \qquad (1)$$

Where Y is to be maximized and represents the difference in net benefits between a policy X (X = 1, 2, 3...n) and the best alternative use of the same resource base. Policy 1 might represent the use of a river for power purposes, Policy 2, the enhancement of the same river's anadromous fish runs and so on. With n policy options to choose from, all have to be compared with each other. The efficient policy choice - that which maximizes net income - is the one which renders Y positive.

The objective function contains the following variables:

$(B - C)_1$	The present value of net benefits (gross benefits minus gross costs) of power development on the river.
$(B_a - C_a)_1$	The opportunity costs (i.e. the value of the net benefits foregone) of not investing in the next best alternative power source.
$(B - C)_2$	The present value of net benefits (gross benefits minus gross costs) of fish enhancement on the river.
$(B_a - C_a)_2$	The opportunity cost (i.e. the value of the net benefits foregone) of not investing in the next best alternative fish source.

Consideration must be given to all public and private projects which form part of or are induced by each development alternative.

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[1] For a more complete analysis, see Peter O. Steiner, "Choosing Among Alternative Investments in the Water Resource Field", A.E.R., Vol. 49, 1959. Also Martin S. Feldstein, "Opportunity Cost Calculations in Cost-Benefit Analysis", Public Finance, Vol. XIX, 1964.

The meaning of the first part of equation (1),

$$(B - C)_1 - (B_a - C_a)_1 \tag{1a}$$

should now be clear. It represents the net present value of power development minus the opportunity costs in all sectors of the relevant economy, other than the opportunity costs represented by fish enhancement in the second part of equation (1),

$$(B - C)_2 - (B_a - C_a)_2 \tag{1b}$$

The second half of equation (1) can be interpreted in exactly the same way. It represents another alternative utilization of the same resource base. To repeat, with n patterns of resource utilization to choose from, the efficient policy choice is the one which renders Y in equation (1) positive.

2.2.6 Complicating Factors

2.2.6.1 The Benefit Side

In order to discuss the basic concepts involved in evaluating benefits and costs of a project (willingness to pay, economic rent and opportunity cost, respectively) we have purposely been dealing in a world simplified by the assumptions defining the standard project. However, within this restricted context, we have suggested means of adequately approximating willingness to pay, economic rent and opportunity cost on the basis of information which is likely to exist in a variety of actual situations. It is now appropriate to recognize that all project benefits may not be amenable to straightforward evaluation by one of the three methods suggested above. In order to explore the full range of benefit measurement problems, the analyst might conceivably encounter, we therefore drop assumptions ii. and v. and now admit the possibility of project benefits whose value is not determined by normal market relationships. These non-marketed benefits include:

-- production efficiencies enjoyed by firms related to firms who are direct beneficiaries of the proposed project - the so-called technological external economies.

-- the value of goods and services provided by government free of direct charge.

2.2.6.1.1 Technological External Economies

Increased output on the part of firms directly affected by the installation of the project may result in the adoption of more efficient productive processes by firms related to the direct project beneficiaries. The result may be either:

i. increased output on the part of the related firms,

ii. a reduction in the quantity of input resources required to maintain the pre-project level of output.

Quite clearly, technological external economies may create a ripple of induced economic activity when the project output is used in whole or in part as an intermediate good or service. The net value of this additional activity should properly be included among the benefits of the project. The value of such technological external economies should be measured by the net income increase of the firms related to the direct project beneficiaries. In practice, measurement of the net income increase may be difficult due to paucity of information or simply to the proprietary nature of this type of information. Nevertheless, in situations in which production efficiencies are expected to take place and particularly where these are thought to be significant, the analyst should make an attempt to estimate the net income increase of related firms.

GUIDELINE:

Technological external economies are measured by the net income increase of firms related to direct project beneficiaries.

2.2.6.1.2 Other Non-Marketed Benefits

Frequently, the output of projects in the public sector is provided free of direct charge to the user of the good or service. A well-known contemporary example of this situation is the provision of recreation services either directly through a system of provincial, regional district and municipal parks or indirectly as a by-product of public projects designed to serve other purposes, e.g., a storage reservoir behind a hydroelectric generating facility. It is now commonplace to find dollar value estimates of recreation benefits stemming from such a project included along with the valuation of electric power and other marketed benefits. Of course, recreation benefits are not the only type of non-priced user benefit resulting from public investments.

Other projects whose benefits are frequently unmarketed and unpriced directly to the user are urban and rural flood control, construction of new highways, upgrading of existing highways, sewage disposal systems, many municipal water supply systems, and so forth.

For several reasons we have chosen to discuss the methodology of valuation of recreation benefits at some length in this set of guidelines. The types of public investment projects to which the evaluation guidelines proposed herein will be applied, will frequently involve either the provision or preclusion (or both) of recreation resources whose value may be significant. This is particularly important in view of the allegedly changing status of natural amenities and outdoor recreation vis á vis manufactured goods and services[1]. It will therefore be important for project analysts to understand the methodology involved, along with its conceptual and practical limitations.

Recreation evaluation has been discussed in the economics literature for a number of years, yet its study is still very much in its infancy and the methods of application relatively undeveloped. The result is a variety of valuation techniques which, if applied to a particular resource, could produce rather widely divergent values. Finally, while valuation of some of the other types of benefits of public investments mentioned above can present problems, on the whole the methodology is more generally accepted than that applying to recreation valuation. The discussion begins with an identification of the components of the value of a recreational resource.

(a) Components of the Value of a Recreational Resource

A recreational resource possesses three distinct value components - exchange value, option value and existence or preservation value. The latter two components have only recently been formally distinguished. Exchange value is that value which results from direct consumption of the service by present users. It corresponds to the area beneath the demand curve as described in section 2.2.3. This area represents the users' willingness-to-pay for the service. Option value is that value which risk averse[2] individuals who are uncertain future demanders of the service are willing to pay to retain the option of consuming the services in the future. Existence value represents that amount which individuals who are certain not to use the resource in the future are willing to pay simply to retain the knowledge that the resource is 'still there' or to bequeath the resource to future generations. In attempting to measure the value of a recreational resource it is desirable, of course, to use methods which enable the analyst to capture in full the associated values. We turn now to a brief review of the methods presently used to evaluate the various components of a recreational resource.

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[1] Krutilla, John R., "Conservation Reconsidered", American Economic Review. Vol. L, No. 4.

[2] Individuals willing to pay a small certain sum (a premium) in order to avoid a relatively large uncertain future loss.

(b) Indirect Methods: Travel Cost and Transfer Cost

Demand schedules for recreational experiences have been derived from variations in travel cost and the associated observed variations in visit rates. This approach treats demand for recreation resources in the same manner in which demand for other goods and services is treated, i.e., the consumer is assumed to be rational, balancing marginal satisfaction against marginal cost. Accordingly, it is assumed that one may impute willingness to pay from indirect evidence on observed behaviour, in this case, the consumer's willingness to incur travel cost.

Application of the indirect technique requires a significant amount of data on recreationists' incomes, distances travelled, travel cost, number of individuals in the party, etc. The approach generally is to stratify a sample of the user population according to distance from the recreational opportunity, income, family size, etc., Zones are established by inscribing concentric circles around the recreation resource. Zonal participation rates are then related to travel cost. One may then predict the participation rate for any population group from the observed participation rate of similar populations with travel costs equal to those of the group in question plus a toll. By applying these participation rates at various levels of toll to the number in each population group and aggregating for all groups, a demand curve results. This curve might apear as in figure 2-3 below.

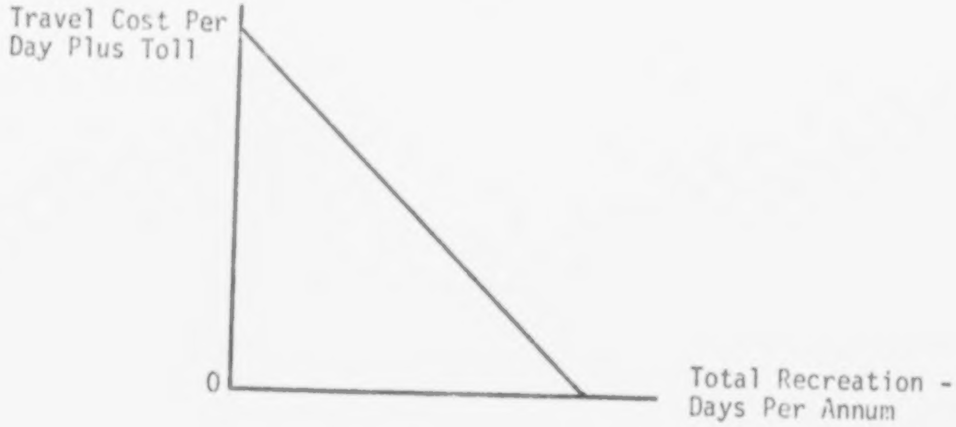

FIGURE 2-3

The annual value generated by the recreational resource is represented by the area of the triangle inscribed by the demand curve, assuming that no toll or price is charged. The total value of the resource to be included in a benefit-cost study would be the sum of these annual values compounded to some future year at the social opportunity cost rate of discount.[1]

A variation on this general theme was employed by a group of researchers in Oregon who postulated that the costs of participating in a sport fishery (transfer costs) varied directly with distances from the fishery. This postulate was based on the observation that distant anglers usually rented motels, ate in restaurants and chartered boats while local anglers did not. Thus, a relation between variable cost per day and angler days could be developed. From this relationship a demand curve was constructed by posing the rhetorical question, "if one increases costs by x for anglers, how many days will those anglers fish?" For each zone one then relates days-fishing per angler (participation rate) in that zone (at various increased variable costs) to total angler population in that zone. For all zones, total days of fishing may then be assessed at various levels of additional costs. The demand curve thus established would appear as in figure 2-4 below.

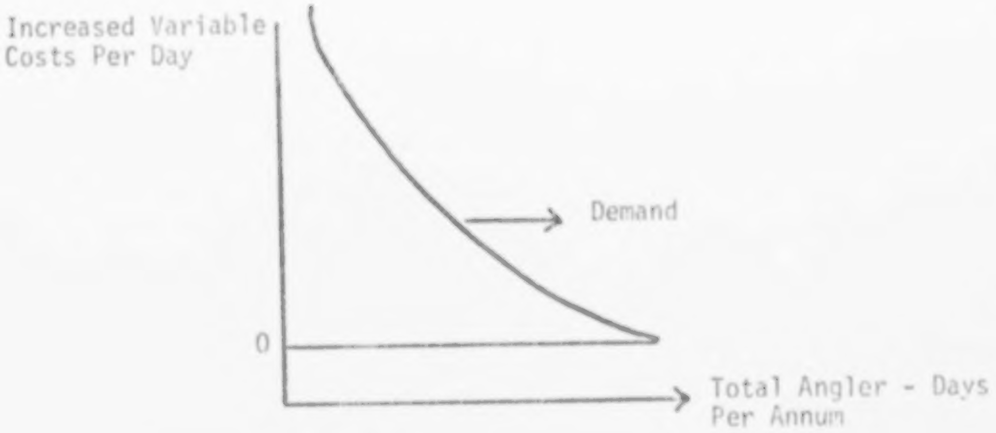

FIGURE 2-4

The annual value of the recreational resource is the area inscribed by the damand curve. This corresponds to annual consumer surplus, assuming no toll or fee is levied. The total value of the resource is calculated in the same manner as described above.

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[1] See Chapter 4 for further detail on the discount (compound) rate and the compounding procedure.

A further variation on the travel cost method was developed and applied by Pearse.[1] He grouped data according to the usual categories and assumed that the individual within each income class who incurred the largest travel costs was the marginal recreationist, i.e., received no consumer's surplus. That is, benefit received equalled total cost of consumption for this individual. All other individuals within that income class were assumed to be intra-marginal recreationists who received a measure of consumer's surplus equal to the difference between their own travel costs and the travel costs of the marginal recreationist. Summing this difference for all individuals in each income class and all income classes resulted in an aggregate demand curve for the recreational resource.

In application of any of the above indirect methods, it has been shown in the literature that efficiency in estimation and specification of demand can be improved if data from individual observations is used rather than basing analysis on averages. Also travel cost should be defined so as to include the opportunity cost of the recreationist's time.[2]

The indirect methods briefly described (variations on the Hotelling-Clawson-Knetsch method) above are subject to a number of limitations which we list below.

i. The indirect methods produce an evaluation of the 'total recreational experience' rather than (necessarily) the recreational resource itself. Thus, if individuals derive any utility en route to the resource (including the trip itself), the indirect methods will overstate the value of the resource.

ii. The indirect methods do not reflect the value of income sacrificed by individuals who accept a lower income in order to live closer to the recreation resource.

iii. Land values may be higher in the vicinity of the resource, thus partially offsetting the under-evaluation caused by ii. above.

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[1] Pearse, P.H., "A New Approach To The Evaluation of Non-Priced Recreational Resources", Land Economics. February 1968. pp. 87-99.

[2] Brown, William, A.K. Singh and Jack A. Richards. "Influence of Improved Estimating Technique on Predicted Net Economic Values for Salmon and Steelhead", Oregon State University, Department of Agricultural Economics, 1972 (mimeo).

iv. Tastes may differ from one-distance zone to another reflecting a non-standard market situation faced by recreationists.

v. For more distant recreationists, there may exist a different range of substitute recreation opportunities which constitutes an additional factor contributing to non-comparable market situations.

vi. A consistent relationship between travel cost and distance is difficult to establish due to the existence of a variety of modes of travel and the effect of time constraints on the choice of mode.

vii. Purchase of durable goods may be a substitute for variable trip expenses. Theoretically, a cost allocation should be made so as to reflect a portion of the user cost of such items along with travel cost estimates. This would be difficult in practice.

(c) Direct Methods: User Opinion Questionnaires

A different approach to evaluation of recreation activities is to directly ask recreationists a series of evaluation questions. Given proper phrasing of the questions and assuming that respondents understand the questions and will answer honestly, estimates of value can be obtained. The questions must specify the recreational activity, the time and place of the activity and any other variables necessary to fully inform the respondent. Generally, on-site interviews are thought to be less hypothetical than off-site and, other things equal, should result in more accurate responses. The emphasis in application of this technique should be placed on development of an unbiased questionnaire and interview procedure. A series of cross referencing questions can and should be devised so as to check the consistency of the responses of the interviewee.

Two basic evaluation questions require answers. One is the willingness to pay question, i.e., what is the largest amount you would be willing to pay to....(specification of activity, time, place, etc.)? The other question involves asking the respondent how much he would have to be paid to give up his right to engage in a certain activity in a certain place at a specified time, etc. Answers to the two questions should differ. The willingness-to-pay question presumes the continued existence of the resource while the latter (the bribe question) presumes that the respondent will give up his 'right' to use the resource. Which question is appropriate for evaluation will be a matter for discussion below.

The direct technique is also subject to a number of limitations.

i. The most obvious and well-known shortcoming of the direct questioning technique is the potential for hypothetical questions to result in hypothetical responses. This difficulty may be compounded by the motivations the respondent ascribes to the interviewer. If the respondent feels that his response will be used as a basis to set charges, prices or tolls, he is likely to respond with a low estimate of value. Conversely, if he perceives that the continued existence of a recreation resource is in jeopardy, he may respond with a high estimate of value. This problem can be mitigated most effectively by checking estimates generated by this technique with estimates derived by one of the indirect methods.

ii. Another significant problem with the questionnaire technique is that of substitutability and time frame. A recreationist might put a lower value on his opportunity to consume a particular set of recreation services in a given location this year because he is aware that he can consume a similar set of services this year in another area. Thus, his response to an evaluation question on each of these substitute areas separately would not in total be the same as his response to an evaluation question regarding what bribe he would accept to give up all his recreational opportunities this year. The time frame of a bribe evaluation question should be similar to the period over which the evaluation will take place. Thus, a yearly value obtained from a bribe evaluation question regarding recreation this year cannot reasonably be capitalized over many years. Yet if recreationists are faced with a bribe question regarding rights to use a recreation area for, say, fifty years or in perpetuity, their answers are likely to be extremely hypothetical

> since it is likely to be difficult for recreationists to relate to this lengthy time span. Also, inclusion of a time frame in the question may reveal to the respondent the motivation for attempts to evaluate a particular recreational resource.

(d) Standard Values Per Recreation Day

The Water Resources Council in the United States has adopted the convention of specifying a range of recreation day values to be used in the evaluation of water resource projects. Two separate ranges were recommended, one reflecting a range of values for general recreation, the other a range to measure the value of specialized recreation. This approach to recreation resource evaluation has been criticized on a number of grounds. The criticisms boil down to the fact that the specified ranges do not allow adequate recognition of the influence of the availability of substitute recreation resources on the value of the resource in question. The standard values account for direct use only and make no allowance for potentially significant option value and existence value. Additionally, the use of standard values may impede the development of more satisfactory methods of recreation resource evaluation.

(e) Establishing Guidelines for Recreation Evaluation

The project analyst may be faced with one of two general problems when evaluating recreation resources.

i. An existing recreational resource must be evaluated so that its value may be compared with that of a competitive use of the existing resource base.

ii. Resources having a variety of alternative uses are to be diverted from those uses in order to provide new recreational opportunities (possibly as joint products with outputs of other goods or services). This situation includes the evaluation of a marginal increase in the quality of a resource; e.g., expenditures undertaken to improve the quality of an existing hunting or fishing opportunity.

The appropriate valuation technique to apply will depend upon which of these two general problems characterizes the case at hand.

While none of the techniques reviewed above was found to be entirely satisfactory, in order for benefits of recreational resources to be included in project evaluations, some method must be employed. For purposes of recreation evaluation in British Columbia, we recommend the following procedure. Where the appropriate measure of consumer surplus is given by willingness-to-pay (compensating variation) a variant of the travel cost method should be employed. When using these techniques, consideration should be given to inclusion of an allowance for the opportunity cost of the recreationist's time. Above all, the methodology, sources of data and assumptions should be fully and clearly documented so that the procedure followed is clear to the reader of the study. It is recognized that the indirect methods establish a compensating variation measure of consumer surplus and that this is the appropriate measure for case ii.

For case i, compensating variation is also the proper measure but must be estimated from the standpoint of a change in the law of liability which views the recreationist as having rights to the resource. These rights must be 'purchased' by the proponents of alternative land use options.[1] In case i circumstances, the travel cost variants produce a minimum estimate of the value of the recreation services. Thus, the direct question method is conceptually superior in these instances. However, caution must be exercised so as to avoid, to as great an extent as possible, the weaknesses of the direct question method. Additionally, the analyst should avoid the temptation to 'justify' a high value for 'defensive' strategies. The role of the economist is to uncover, to the best of his ability, the facts concerning resource allocation decisions.

We have reached a hiatus in our discussion of recreation resource evaluation. The appropriateness of the conceptual value measured by a direct technique has been established for case i valuation problems. Yet it is with some trepidation that the Working Group on Benefit-Cost Analysis finds the direct method acceptable. Clearly none of the recreation resource evaluation methods is above criticism. Nevertheless, it is argued that it is less likely for the analyst to steer too wide of the mark when employing a travel cost method. Behind this is the 'gut' feeling that to err on the conservative side is somehow a good thing. Of more concern to the Working Group than the theoretical superiority of one method over the other is the manner in which either method is applied to particular cases. Thus, while both methods are acceptable in principle, the Working Group will judge the merits of each application in relation to the method of application.

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[1] Here again the issue of legal liability arises. However, in many 'development versus preservation' cases, the land or related resource is publicly owned and it is correct to view the valuation question in this light. It would be entirely inappropriate to ask the owners of a resource what they would be willing to pay to retain it in a particular state. For more on this see E.J. Mishan, Cost-Benefit Analysis, Chapters 18-21.

GUIDELINE:

For evaluation of recreational resources, either the direct or indirect method may be employed as warranted by the circumstances of each case. Care must be exercised in documentation of sources and assumptions. Each application will have to stand on its merits and in this respect, a well-reasoned and well-documented analysis stands a greater chance of general acceptance. Where information, data and/or funding are in short supply, application of standard values per recreation day is acceptable.

(f) Option Value

Forecasting the future value of output streams must concern itself with changes in technology, employment, tastes and income. The future value of all these variables is uncertain. When uncertainty in future demand caused by the above is possible, Weisbrod[1] has pointed out that an additional value, namely option value, must be considered when three conditions hold:

1) if there are individuals who are uncertain about future demand for the commodity or service in question, or who are infrequent consumers. Among these are some who will never use the service.

2) if the future supply of the commodity or service is in doubt in the sense that if a decision is made to curtail supply, re-establishing it would be very costly or even technically impossible.

3) if there is no practical way for resource owners providing the service in question to collect the option value because exclusion (i.e., inability to identify all who would benefit from assured availability and to exclude same for failure to pay the premiums) is not possible.

The discussion following Weisbrod's conception of option value has centered around the questions:

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[1] Burton A. Weisbrod, "Collective Consumption Services of Individual Consumption Goods", Q.J.E., Vol. 78, 1964, pp. 471-477.

1) What is the relationship between expected consumer surplus and option value?[1]

2) Is option value over and above expected consumer surplus any more than just a premium for risk?[2]

3) Can such risk be pooled?[3]

4) If so, is it necessary for public investments to make any adjustment for option value?[4]

The latest word on these issues has been provided in the recent articles by Arrow and Lind, and Arrow and Fisher. Corresponding to the questions above, we have the following tentative answers. Option value exists over and above expected consumer's surplus under conditions of risk aversion. Whether risk aversion should be taken into account in public decision-making or not depends on whether the risks involved can be pooled. (A discussion of risk and uncertainty is taken up in greater detail in chapter 3). This in turn depends on the distribution of benefits and costs. If benefits and costs are widely distributed, no risk premiums should be allowed for. Given that pooling is possible, however, a kind of risk-aversion premium can still be justified if irreversible decisions are involved. A fairly voluminous literature would seem to boil down to the following: "The expected benefits of an irreversible decision should be adjusted to reflect the loss of option it entails".[5] The key here is the distinction between reversible and irreversible changes in the environment. Arrow and Fisher provide the following advice to policy-makers:

> "If we are uncertain about the payoff to investment in development, we should err on the side

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[1] Millard F. Long, "Collective Consumption Services of Individual Consumption Goods: Comment", Q.J.E., Vol. 81, 1967, pp. 351-352. Cotton M. Lindsay, "Option Demand and Consumer's Surplus", Q.J.E., Vol. 83, 1969, pp. 344-346. D.R. Byerlee, "Option Demand and Consumer's Surplus: Comment", Q.J.E., Vol. 85, 1971, pp. 523-527.

[2] Charles J. Cicchetti and Myrick Freeman III, "Option Demand and Consumer's Surplus: Further Comment", Q.J.E. Vol. 85, 1971, pp. 528-539.

[3] Kenneth J. Arrow and Robert C. Lind, "Uncertainty and the Evaluation of Public Investment Decisions", A.E.R., Vol. 60, 1970, pp. 364-378.

[4] Kenneth J. Arrow and Anthony C. Fisher, op. cit.

[5] Arrow and Fisher, ibid., p. 319.

> of under-investment, rather than over-investment, since development is irreversible. Given an ability to learn from experience, under-investment can be remedied before the second period, whereas mistaken over-investment cannot, the consequences persisting in effect for all time".[1]

The analysis of irreversible development has received growing attention in the literature. Where environmental losses are envisaged, irreversibility in itself produces a bias against development. The introduction of uncertainty and the idea that new information will be forthcoming in the future, leads to a further bias. However, the admission of option value has yet to be made quantifiable in any non-controversial fashion.

GUIDELINE:

Inasmuch as option value cannot be measured in any non-controversial fashion, its use in a benefit-cost study is precluded. Qualitative statements will have to suffice.

(g) Existence Value

A related category of non-user benefit has been referred to as existence value. This value accrues to individuals who, while they do not directly participate in using the recreational resource, receive benefit from the simple knowledge that a particular resource has been preserved against development. This value is said to accrue in spite of the certain knowledge on the part of these individuals that they will never use the resource. 'Bequest motivation', i.e., the desire to preserve 'natural areas' for future generations is seen as part of existence value.

GUIDELINE:

Like option value, existence value has not presently proven to be measurable in any non-controversial fashion. Thus, there is no means of including it among the efficiency effects of the project evaluation.

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[1] Arrow and Fisher, ibid., p. 317.

2.2.6.2 The Cost Side

Negative spillover effects (i.e., extra-market effects resulting from the project which nevertheless impinge on other sectors of the economy) may be broadly classified into two categories.

i. spillover effects impinging on firms' production processes.

ii. spillover effects impinging on individuals' consumption processes.

Ultimately, of course, category i effects work their way through the interconnected economy and affect final consumption processes of individuals. The dichotomy also breaks down for spillover effects which simultaneously affect production and consumption activities. Nevertheless, for purposes of discussion (and for measurement too, as we shall see), the categorization is useful.

2.2.6.2.1 Indirect Production Inefficiencies - Technological External Diseconomies

Technological external diseconomies are those non-market effects which cause firms related to other firms directly affected by the project to be less efficient (and therefore presumably produce less output). Several examples should suffice to convey the idea. Consider a pulp and paper mill proposed to be constructed upstream of a bottled water plant and in the same airshed as an historic and fashionable resort hotel. If the paper mill is constructed, the bottled water plant may be required to install new distillation equipment in order to handle the now larger quantities of residue. In addition, the equipment may wear out more rapidly or become fouled more frequently, or both. All these factors serve to increase the costs of the water plant. Whether these increased costs cause the water plant to change its position on its cost curve (as would be the case in perfect competition) or cause it to raise the price of the output (as it probably would assuming some form of imperfect market structure), the result is the same - increased unit prices for bottled water along with decreased production and consumption of same.

Moving to the resort hotel, we find that the guest list is no longer as full as it once was. Some of the 'old-timers' continue to make their annual visits. Perhaps they find the enjoyment of reminiscing about fond memories sufficiently beneficial that it outweighs the disbenefit of the pervasive sulphur odor. But the younger people now take their holidays elsewhere, presumably preferring cleaner air. These two examples provide rather obvious cases of production inefficiencies inflicted by a project on other firms. Many diseconomies are much more subtle, difficult to detect and measure. For example, the long-term health effects of workers' exposure to chemicals and harmful agents in their place of work.

Measurement of external diseconomies is symmetric with the measurement of external economies. The net income decrease of the firms suffering diseconomies should be taken as an approximation to the decline in value added to the final value of consumer goods and services.

The symmetry with external economies continues through to the effect that changes in the price of output or quantity of output may have on firms related to those firms which suffer directly from a diseconomy. Here again, net income decrease may be taken as a proxy for the decline in value added to final consumer goods at this stage of production.

It is again necessary to remind the reader of the earlier comments concerning net income change as a measure of the social value of external economies and diseconomies. Judgment must be exercised in its use to ensure that it approximates reasonably accurately the value which it is designed to approximate.

GUIDELINE:

Technological external diseconomies are measured by the decrease in net income of firms directly related to other firms affected by the project.

2.2.6.2.2 External Diseconomies in Consumption

Just as it is possible for production processes to interact and cause each other trouble, as was shown above, so also can production processes interact with consumption processes, again causing difficulty. Indeed, it is possible for consumption processes to interact with each other as suburban Saturday evening barbequers are fully aware. However, in this document we are most concerned with production/consumption interactions since these are the normal results of development projects.

Quite unlike production externalities, most consumption diseconomies are notional and accordingly do not have a readily identifiable or measurable monetary counterpart. In our earlier pulp mill/hotel example, the younger guests (we assumed) were induced to seek their holiday enjoyment elsewhere. Other things equal, had they preferred to visit the historic resort hotel, we must presume that a decline in economic welfare has occurred. Similarly, with most adverse environmental impacts of this nature, we may presume they adversely affect individuals' consumption satisfaction. However, since the declines in such satisfaction are notional, measurement in a non-controversial fashion is difficult. Again, it is necessary to refer the analyst to a later section of the Guidelines in which section a satisfactory approach to handling this difficulty is developed.

GUIDELINE:

The value of consumption externalities cannot be estimated directly; such diseconomies cannot therefore be included among the efficiency effects of the project evaluation. Alternative methods of handling the problem will be considered in a later chapter.

CHAPTER 3

ADJUSTMENTS FOR INFLATION, RELATIVE PRICE CHANGES, RISK AND UNCERTAINTY, UNEMPLOYMENT AND MARKET IMPERFECTIONS

3.1 Introduction

This chapter deals largely with the subject of price imputation which poses some very difficult issues in project evaluation as is evidenced by the array of subject-matter headings in the chapter title. In some of these areas there is more or less general agreement among economists as to how to handle these problems conceptually. This is true of inflation, relative price changes and, to some extent, unemployment and market imperfections.[1] In these instances, practical means of making the necessary adjustments are also available. In other areas, e.g., risk and uncertainty, even a full explication of the theory is lacking. Therefore, only a rough and ready handling can be recommended.

In bridging the gap between theory and application, the difficulty in the former class of problems is that we quickly encounter that ubiquitous problem in benefit-cost analysis - the measurement problem. Unfortunately, that universal condition of economics - ceteris paribus - is inoperative in most applied problems and it is not possible to measure the effects of changes in a controlled, laboratory type experiment. In most cases, we shall attempt to meet the measurement problems head-on by recommending methods of proceeding in spite of limited information. Hopefully, near term developments in research will lead to increasingly more satisfactory solutions to the measurement problems, data gaps, etc.

3.2 Changes in the General Price Level

Project evaluation during periods of inflation is a relatively contemporary area of concern since protracted periods of inflation are new to the North American economic scene. During the 1950's and 1960's when prices remained fairly stable, few economists bothered to consider how inflation would affect major project evaluation. (For example, in January, 1960, the Vancouver Consumer Price Index had a value of 78.6 (1971 = 100) and in December, 1970, the value was 97.7, while the December, 1974, value had jumped markedly to 131.4).

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[1] Unemployment may be classed as a market imperfection. However, the latter term as used here, refers to defects in the industrial structure of various markets.

As it turns out, the only consideration one must give to evaluating projects during inflation is to ensure that the prices used to evaluate benefits and costs are stated on a basis consistent with that of the discount rate employed to reduce time streams of net benefits to a common point. As we shall discover immediately below, there are two options to consider. Throughout the discussion it must be remembered that inflation is defined as a change in the general level of prices. The following section takes up the problem of the manner in which relative price changes affect project evaluations.

Fortunately, much of this ground has been covered by recent research published in the journal Water Resources Research.[1] The technical details are developed there and we shall extract only that necessary to develop the argument. The following symbols will be used to portray the necessary relationships.[2]

d_b	one current dollar at the beginning of the period
d_e	current dollars at the end of the period such that a representative individual is indifferent between d_b and d_e
e	the amount of constant (inflation-free) dollars at the end of the period such that in terms of purchasing power a representative individual at the beginning of the period would be indifferent between d_b and C_e
R	the inflation free rate of interest
t	the nominal or money rate of interest
I	the expected rate of price change.

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[1] Steve H. Hanke, Philip H. Corner and Paul Bugg, "Project Evaluation During Inflation", Water Resources Research, Vol. 11, No. 4, August 1975, p. 511.

[2] Ibid., p. 511.

In real terms, an individual would be indifferent between d_b and C_e only with a premium of Rd_b, i.e.,

(1) $C_e = d_b (1 + R)$

In nominal (money) terms, current dollars at the period's end are constant dollars at the end of the period multiplied by one plus the rate of inflation. Symbolically

(2) $d_e = C_e (1 + I)$

Beginning the period with d_b current dollars, one would require current dollars at the period's end as given by

(3) $d_e = d_b (1 + t)$

in order to be indifferent. Substituting (1) into (2) yields

(4) $d_e = d_b (1 + R)(1 + I)$.

By substituting (3) into (4), we have the relationship between nominal interest rates, real interest rates and the rate of inflation as shown below

(5) $1 + t = (1 + R) (1 + I)$.

This simplifies to

(6) $t = R + I + RI$.

In most of the early benefit-cost literature it was thought that the product RI was small. Indeed if I is 2% per year and R is 5% per year, RI = 0.001, a rather small number. But with I approximately 10% and R also approximately 10%, RI = 0.01 not an inconsequential addition to t.

We may use equation (6) above to develop the two options for handling inflation in benefit-cost analysis. Option (1) is to calcualte the present value of net benefits by forecasting both prices and interest rates in real terms. For option 1 we would employ equation (1) to find the value of C_e given the value of d_b and the discount rate R. Option (2) is to calculate the present value of net benefits by forecasting both prices and interest rates in nominal (current) terms. For this option we would employ relation (4) to find the value in current dollars at the end of the period, d_e, given d_b, the value at the beginning of the period, the real rate of discount, R and the anticipated rate of inflation, I.

The two options will yield exactly the same result so long as both prices and interest rates are projected on a consistent basis. This can easily be seen by the following logic. Option 1 uses the relation $C_e = d_b (1 + R)$ and option 2 employs the relation $d_e = d_b (1 + R)(1 + I)$. But from equation (2), we know that $d_e = C_e (1 + I)$. Substituting this into the option 2 relation yields $C_e (1 + I) = d_b (1 + R)(1 + I)$. Cancelling the common (1 + I) terms, we have $C_e = d_b (1 + R)$ which is the option 1 relation.

In the chapter which follows, a social opportunity cost of capital based on rate of discount is recommended for evaluating time streams of benefits and costs. This rate of discount is a real rate.

For consistency in respect of the above discussions, we recommend that the price used in projecting benefits and costs of projects be forecast in real terms. This is the simplest procedure since it avoids the problem of forecasting the rate of inflation and the rate of interest over a long span of time.

GUIDELINE:

The overriding criterion for dealing with general price changes in project evaluations is consistency in the handling of discount rates and prices. For project evaluation in British Columbia, we recommend that prices be forecast in real terms.

3.3. Changes in Relative Prices

Changes in the relative prices of the outputs of a project and/or the inputs necessary to maintain and operate the facility can markedly affect the economics of the project. For example, one suspects that the new, higher prices of coal, heavy fuel oil and natural gas have substantially altered the relative costs of thermalelectric versus hydroelectric generating facilities. Another example is the increased awareness of the value of environmental quality and the assets provided by nature. This increased awareness can be expressed as a change in the price (value) of natural amenities vis-a-vis produced goods and services as has indeed been suggested and analyzed in some detail by J.V. Krutilla. One suspects that some projects constructed in the past would not pass muster if contemporary prices and values were applied in their evaluation. The point is that anticipation of changes in relative prices may be a vitally important part of project evaluation.

In any particular case, lack of knowledge of the future and general paucity of information will hamper efforts to account explicitly for relative price changes.[1] Nevertheless, awareness that substantial shifts can take place as evidenced by recent experience should be a lesson learned.

The suggested method of dealing with forecasting future relative prices contains a number of steps, the first of which is a rough analysis involving a percentage breakdown of the contribution to total benefits and costs of a project made by major category of benefits and costs, assuming the structure of relative prices at the time of evaluation. This will assist in isolation of major benefit and cost elements which may be subject to change for the particular project under study. With this information, the analyst must make a judgmental determination of the benefit and cost elements most likely to change, if any. Having segregated the major components subject to potential change, the analyst must conduct a 'mini' benefit-cost analysis to determine whether any of the major components identified could experience a change in relative price sufficient to have an effect on the conclusions of the project evaluation. This could be accomplished by sensitivity analysis, i.e., constructing several scenarios of relative prices and running through the project evaluation for each scenario separately. If a substantial range of relative price scenarios are tried and conclusions on the project(s) do not change, then the analyst is probably justified in concluding directly that no further research into actual relative price trends is justified. If the project rankings or evaluations are altered, then it is likely that some further research is required. The kind or quality of research to conduct in these circumstances is really a matter of degree.

The final step in this process is to determine the appropriate extent of the effort to put into obtaining additional information. The 'benefits' of additional information must be judged in light of the sensitivity analysis conducted in step 2. The 'costs' of the effort may be judged in terms of staff time, computing time and delays in the completion of the project evaluation.

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[1] For a detailed discussion of the handling of risk and uncertainty see the last section of this chapter.

A discussion of the type of research to conduct has been purposely omitted on the assumption that to have discussed this point may have unnecessarily curtailed the ingenuity of the individual analyst. The operating assumption is that anyone capable of conducting a proper benefit-cost study along the lines recommended in these Guidelines will be capable of conducting the appropriate type of price trend analysis in given circumstances. The thrust of the discussion has rather been to indicate the extreme importance of relative price changes on projects whose benefits and costs accrue over long spans of time and to indicate that more than prefunctory assumptions about relative prices is required for a project evaluation to pass muster.

GUIDELINE:

Forecast future changes in relative prices must be taken into account in a project analysis. The assumption that relative prices will not change requires the demonstration that some analysis has preceded this conclusion. The conclusion that relative price changes, if they occur, will not markedly affect the ranking of the project(s) or the value of the investment criterion for that project must be demonstrated through some type of sensitivity analysis as described above. Clearly, this guideline applies to prices employed to calculate both benefits and costs.

3.4 Unemployment and Excess Capacity

3.4.1 Unemployment and Under-Employment of Labor

Under normal circumstances, we assume that market prices represent the social value of the goods or services to which they attach. This was the operating assumption adopted in Chapter 2 when the 'standard project' was discussed. If unemployment or excess capacity exist and if the idle resources are employed in the project under evaluation, the social cost of the project is less than the amounts actually spent on wages and raw materials, etc. This is the result of the application of the concept of opportunity cost. If, in the absence of the project, idle resources would have remained idle, producing nothing of value to society, then society sacrifices no alternative goods or services by using these idle resources in the construction, operation and maintenance of the project in question.

Consistent application of the concept of opportunity cost requires that recognition be given to the possibility of idle resources being drawn into production in the construction of a public project. Let us be clear that the application of the concept of opportunity cost is the rationale behind the argument in favor of 'shadow pricing'.

In the earlier days of the application of benefit-cost analysis to public projects (early post-WW II era), shadow pricing of unemployed or under-employed resources was justified on the basis that public projects were countercyclical measures. Subsequent research and thinking now tends to downplay this aspect. Frequently due to delays in administrative decision-making and commencement of construction, public projects may tend to aggravate rather than alleviate the business cycle. Accordingly, public projects must be justified on other grounds. Where persistent employment remains a problem and can be forecast to be such in the absence of the project, a reduction of wages, salaries and material costs should be made in order to account for the 'employment benefits', i.e., the lower social cost of constructing, operating and maintaining the facility with otherwise unemployed factor inputs.

Operationally, adjusting for unemployment is no simple task. The adjustment of wages and salaries to reflect social cost carries all the same difficulties as the forecasting of relative prices discussed in an earlier section. In addition, there are new problems to resolve. The major steps involved in this analysis are as follows:

i. Segment manpower requirements into major trades required for construction of the project.

ii. Obtain provincial unemployment rates for each of these trades.[1]

iii. Use unemployment rates as obtained in ii. above to forecast unemployment rates through the construction period of the project. Here, regression analysis would be preferred, but presently the unemployment series referred to above is of insufficient duration to support this kind of analysis. The passage of time will eliminate this problem.

iv. Use the unemployment rates as forecast in iii. to determine the probability of drawing an unemployed worker into the construction of the project. In one of the few empirical studies on this topic, Haveman and Krutilla have postulated a relationship between the unemployment rate and the probability of hiring a worker from the unemployed pool.[1] In lieu of the estimation of such a curve for Canada, the Haveman and Krutilla curve should be used.

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[1] This data is available from the Unemployment Insurance Commission offices in Vancouver. At the moment the program is being administered by Bill Nellis.

v. Apply sensitivity analysis to the forecast unemployment rates to investigate the sensitivity of results to changes in unemployment rates.

For most major investment projects, the referent area for labor inputs is the entire province. The sub-trade unemployment rates published by the Unemployment Insurance Commission will therefore suffice. In the event that a particular project draws from a more localized labor force with an unemployment rate different from that for a given trade on a province-wide basis, adjustments may be made to the probabilities which make up the labor response function, i.e., the relationship between the unemployment rate and the probability of drawing a laborer from the unemployed pool. Such adjustments should be fully documented with sources of data and the rationale underlying the adjustments.

The existence of an unemployment insurance benefit scheme may confuse the appropriate handling of unemployment in project evaluation. Clarification is therefore warranted. Unemployment insurance benefits are to be regarded as transfer payments from the working members of society to the currently non-working. Such payments represent consumption of part of the net social product by society's non-working members. But the payments are not the unemployed's opportunity costs since they represent no sacrifice of output. We conclude that even in the presence of an unemployment insurance scheme, the opportunity cost of unemployed labor is zero.

3.4.2 Excess Productive Capacity

The existence of excess labor supply likely signals the existence of idle productive capacity as well. The same rationale behind the adjustments to reflect the social opportunity cost of employing previously unemployed labour applies equally to unemployed capital resources, mutatis mutandis. Haveman and Krutilla[2] employed the same input-output structure to analyze both the labor and capital demand generated by particular types of public investment projects. With their input-output structure it was possible to trace a dollar's worth of final expenditure on the project through the model and find the point at which the expenditure became a payment to a primary resource input. Primary resource inputs were defined as employed compensation, net interest, depreciation, corporate profits, indirect business taxes and proprietor income and rent. With this breakdown to value-added components, payments to labor - employed compensation - and capital - corporate profits and net interest - could be singled out.

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[1] R.H. Haveman and John Krutilla, "Unemployment, Excess Capacity, and Benefit-Cost Investment Criteria", American Economic Review, August 1967, p. 382. This data is available from the Unemployment Insurance Commission offices in Vancouver.

[2] op. cit.

A capital response function was postulated on the same basis as the labor response function, i.e., that the probability of using a previously unused unit of capital is a function of the sine of the deviation of the rate of capacity utilization from full utilization This then becomes the basis for an adjustment to the money cost of capital equipment employed in the construction phase.

The procedure for calculating adjustments to the cost of capital equipment is identical to that employed in the adjustment of labor costs. The only additional requirement is a time series of the rates of capacity utilization by industrial classification. This series replaces the series on unemployment rates by trade. At the present time rates of capacity utilization by industry are reported only for Canada in a publication of Statistics Canada entitled "Industrial Utilisation Rates in Canadian Manufacturing by Quarter". However, it is understood that Statistics Canada intends to bring this index out on a provincial basis within a year. At such time, adjustments to the market cost of capital equipment to reflect lower social cost due to unused capacity on a provincial basis will be possible. Until this revised series appears, "shadow pricing" of capital appears infeasible.

GUIDELINE:

In the presence of unemployed labor or unused productive capacity or both, 'shadow prices' should be calculated to reflect the lower social opportunity cost of less than full employment. The adjustments are to be made according to the procedure outlined above and sensitivity analysis should be used as indicated. Calculation of shadow prices for capital will, for the moment, be limited due to data unavailability. However, it is understood that this situation will be remedied in the near future.

3.5 Imperfect Competition

The existence of imperfect competition in either goods or factor markets constitutes a departure from one of the optimality conditions for maximum welfare in a market economy. The result is that the general theory of second best applies. The implication of this circumstance is that optimality conditions become more complex. Very simply stated, if prices in one market are greater than costs in that market by a factor, say k, then the 'price equals marginal cost' optimality rule is broken. If only one market suffers from this condition, then optimality can be restored by adjusting prices in all other markets until they exceed costs by the factor k. However, in general, all markets will experience varying degrees of competition and the value of the k-factors will vary from market to market. In addition, since all markets are interlocked directly or indirectly, an adjustment in one market will have ramifications in all other markets. One can easily see that the only way out of the difficulty is a very large general equilibrium model of the economy.

The degree to which market prices depart from marginal cost represents a welfare loss which society need not bear since it presumably has the power to make markets more price competitive through public policy initiatives if it so desires. That there is no concerted or continual effort to restructure markets along competitive lines suggests either that policy makers do not feel that the price/marginal cost departure is very large or, if large, is justified by the effects imperfect markets have in regard to objectives other than maximizing general welfare. On these grounds it might be considered presumptuous for the analyst to suggest that adjustments to prices and costs should be made to redress the welfare loss effects of imperfect markets in spite of the technical conditions for maximum welfare. Additionally, since the analyst cannot readily determine the direction in which to adjust prices or costs in order to reflect corrected social costs without the aid of a complete model of the economy, it is recommended that attempts to adjust for non-competitive market conditions not be made.

GUIDELINE:

Shadow pricing to reflect welfare gains or losses due to monopoly or generally imperfect competition is conceptually correct but should generally not be attempted in project evaluations in British Columbia. The operating assumption should be that market prices reflect the social value of the resources.

3.6 Risk and Uncertainty

3.6.1 Introduction

The problem of how to treat risk and uncertainty in benefit-cost analysis arises because the outcomes of alternative investments are not predictable with complete certainty. Procedures for treating risk and uncertainty have been developed from capital budgeting, insurance and decision theory. This section explores the problem of risk and uncertainty, examines the alternative techniques for handling the problem and proposes a workable procedure for incorporation into a benefit-cost analysis framework.

3.6.2 Distinction Between Risk and Uncertainty

In contemporary theory, a distinction is normally drawn between risk and uncertainty. Risk refers to situations in which the probability of outcome of a particular sequence of results is less than 1.0 but the probabilities of various possible outcomes can be estimated using statistical information describing the outcome of similar, previous activities. Uncertainty which can be quantified statistically and reduced to an actuarial problem involving objective probabilities derived from historical statistical information is called risk.

When an outcome cannot be predicted using the technique of objective probabilities, the outcome is said to be uncertain. The uncertainty cannot be reduced to an insurable risk. The theory of choice under uncertainty provides several alternative strategies for decision-making when outcomes are uncertain. Of the strategies summarized by Baumol[1] the only strategy which appears to have advanced beyond the theoretical stage is the Bayes Criterion. This strategy involves the use of subjective probability as a means of estimating possible outcomes.

The problem of how to handle uncertainty in benefit-cost analysis is one for which the literature has not yet developed a fully satisfactory solution. Following a review of the types of uncertainty that are likely to arise in applying benefit-cost techniques to project analyses, various procedures for handling the uncertainty problem will be advanced.

3.6.3 Types of Uncertainty

While it is traditional to distinguish between risk and uncertainty, as outlined in the previous section, more recent literature has tended to view risk as a sub-set of uncertainty. The subtle distinction in approach becomes clearer upon a review of types of uncertainty that may be encountered in project analyses.

Little and Mirrlees[2] distinguish between two types of uncertainty affecting any particular project.

One type of uncertainty relates to unpredictable developments in the external environment of a project. These uncertainties would include future changes in technology and consumer preferences, changes in government policy and changes in the prices of project inputs and outputs.

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[1] William J. Baumol, Economic Theory and Operations Analysis, Prentice-Hall Inc., Englewood Cliffs, N.J., 1965, Chapter 24.

[2] I.M.D. Little, and J.A. Mirrlees, Project Appraisal and Planning for Developing Countries, Heinemann Educational Books Co. London, 1974

The other main type of uncertainty relates to the actual performance of the project itself in contrast to the initial plans and expectations. Internal uncertainties would include deviations in the technical and engineering performance of the project from design expectations, variations in the input/output co-efficients, and variations in the economic interrelationships between prices and quantities of inputs and outputs.

The grouping of types of uncertainty into categories is mainly for convenience. In any particular project, it is more important to disaggregate the activities in a project through systematic analysis to identify the sources of uncertainty. In the course of disaggregation, it will normally be possible to identify the variables and to make judgments concerning the predictability of each. Some variables such as the price of one of the outputs or the price of one of the inputs will lend themselves to probability analysis on the basis of historical statistical data. Others such as the delivery time of equipment and the development of new technology will not lend themselves to normal risk analysis techniques.

Howe[1] suggests two general steps to begin the explicit treatment of uncertainty in project evaluation. These are:

"(i) Face up to the uncertainty and acknowledge its presence in as specific a way as possible (e.g., a population may range from 150,000 to 200,000 people, peak residential demand can be assumed to have a particular probability distribution, equipment costs may range from $A to $B and so on).

(ii) Allocate planning resources to the further study of determinants of key economic and social parameters when apparently the range of uncertainty can be significantly reduced through such study."

Howe continues, "A frequently found example of the need to observe point (ii) is the situation in which the physical features of a project will be studied in the greatest detail (e.g., the hydrology will be analyzed and refined, the operating characteristics of lock gates and chambers will be minutely studied and simulated, sedimentation and scouring will be predicted and simulated in detail), whereas only the most naive attempts will be made to study such features as the growth of demand, how the public feels about details of project design, what the impact on aesthetics will be, and so on."[1] The point is that the overall balance between mitigating the problem of risk in the various elements of a project evaluation (engineering, socio-economic, etc.) should be given strict attention. We now turn to the methods of explicitly recognizing risk.

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[1] C.W. Howe, "Benefit-Cost Analysis for Water System Planning", Water Resources Monograph, American Geophysical Union, Washington, D.C., p. 74.

3.6.4 Methods for Treatment of Risk

In this section we shall discuss several of the more frequently suggested methods of dealing with insurable risk in practice. The methods reviewed will be (i) conservatism in estimation of benefits and costs, i.e., high cost estimates and low benefit estimates; (ii) addition of a risk premium to the discount rate; (iii) conservatism in estimating the economic life of the project; (iv) the explicit use of probabilities to calculate expected value.

Conservatism in the estimation of benefits and costs is recommended by the Green Book[2] of the Army Corps of Engineers in the U.S. and was apparently the practice during the 1950's and 1960's. The application of this technique requires the analyst to reduce benefit estimates and increase cost estimates in proportion to the analyst's lack of confidence in the expected values of these variables. This type of handling reflects an unusual and unwarranted view of risk. A more appropriate handling should recognize that future events are perhaps as likely to affect the project in a beneficial way as in an adverse way.

Inclusion of risk factors in the discount rate is another frequently suggested method of handling risk. This method has received considerable currency in the literature - far more currency than is deserved. The procedure here is to adjust the value of the discount rate upward by varying degrees according to the degree of risk associated with various projects.

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[1] Ibid., p. 75.

[2] United States Government. Federal Inter-Agency River Basin Committee, Subcommittee on Benefits and Costs. Proposed Practices for Economic Analysis of River Basin Projects. Washington, May 1950; revised May 1958.

This approach is inappropriate for a variety of reasons. Chief among these reasons is the undesirability of loading the discount rate with 'excess baggage'. Generally speaking, the discounting procedure is one which is difficult enough to grasp and frequently mistrusted by decision-makers. One must argue long and hard to establish the rationale for discounting[1] and to substantiate a particular rate. To load the concept and rate with additional elements is to further cloud the issues. This is even more unfortunate considering the fact that there are other more appropriate means of dealing with risk. Increasing the discount rate compromises the ability of the discount rate to act as arbiter between more and less capital intensive projects. Furthermore, increasing the discount rate to reflect risk indicates a similar and unwarranted aversion to risk, as does conservatism in estimation of benefits and costs. Again, it is entirely possible for things to turn out better than planned as regards a particular project and this is not reflected by upward adjustments.

Another method for reflecting riskiness of projects is the adjustment of payback periods. The payback period is defined as that period over which the accumulated annual net benefits of the project reach a sum equivalent to the capital costs of the project. If risk increases with the length of the payback period then, obviously, the shorter the payback period, the lower the risk. However, the payback period is more an investment criterion than a method of assessing riskiness in projects and must therefore compete with other investment criteria to perform that function. Its use in risk analysis is inappropriate. We shall have more to say about the payback period as an investment criterion in chapter 4.

To this juncture we have rejected all frequently suggested rules of thumb for dealing with risk. In our view, the only really appropriate means of handling risk is to deal with the estimates of benefits and costs directly. While this method may cause more effort to be expended than some of the above, it does meet the criteria set out at the beginning of this section more satisfactorily than the other methods, i.e., it forces analysts and decision-makers to face risk head-on and to make feelings toward risk as it affects benefit and cost estimates explicit.

It may be useful to recall at this time that the most likely sources of risk are changes in the future prices of project outputs, changes in the future prices of inputs required to construct and operate the project and the performance of the physical facility itself. In the discussion surrounding the recommended method of dealing with anticipated price changes, we were actually on the verge of the present topic of analysis - risk and uncertainty. In the discussion of price changes, we recommended the use of sensitivity analysis for cases of anticipated future price changes. We now develop this more fully in relation to explicit recognition of uncertainty and also add several options in addition.

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[1] or compounding. See Chapter 4. However, we argue that the compounding procedure is more easily grasped.

Sensitivity analysis may be used as the precursor to employing the more sophisticated methods for explicitly handling risk. If, on the basis of project evaluation with several scenarios of prices, costs, etc., the project appears to be sensitive to changes in one or more parameters thought likely to change, the analyst should then employ one of the following methods for calculating expected net future value.

3.6.4.1 Method 1

When estimating physical inputs and outputs and the prices of each of these, the analyst should think in terms of determining the expected values of these variables. What this means is that the analyst must average the various possibilities, weighting each possible outcome by the probability of its occurrence. This must be performed for inputs, outputs and prices in each period the project is expected to be constructed and/or operating. Having determined a value for expected returns in each period the analyst compounds these values to determine the expected future value for the project.

It is clearly infeasible to present all possibilities with their associated probabilities. The main point is that the analyst should know what he is trying to estimate and which are the expected outcomes. Three or four separate possibilities is very likely to cover the range of expected variation. In most cases there will be a necessity for project designers to communicate with project evaluators over these points and reach a common agreement on what the possibilities are in fact. The following example illustrates the process.

The first step in applying risk analysis techniques is to sort out the variables, i.e., those elements whose values cannot be determined with certainty, from the remaining fixed or constant elements. In order to reduce the magnitude of the task it may be preferable to treat some of the less important variables as though they were certain.

Each variable is then analyzed separately, and in place of a single value for each, the range within which the variable might fluctuate is defined and the likelihood of the variable occurring at points along the range are established. For example, an important variable in an analysis may be the cost of coal as fuel to a thermal plant. The analyst may examine the problem of choosing the range of prices to use as follows:

Price of coal (ton)	$5	$10	$20	$30	$40
Probability of price occurring	.05	.20	.40	.30	.05

The rationale behind assigning the various probabilities may be as follows: At a coal price of $5 per ton, the producer is able to cover his operating costs only; at $10 per ton, the producer covers his operating and capital costs; at $20 per ton, the producer makes 15 percent profit on the operation; at $30 per ton, the profit level is greater than normal for the industry and other investors will be attracted to invest in coal. Finally, at $40 per ton, the profit level is so high that the expectation must be that market forces will force down the price, but there is still a 5 percent chance that the coal producer can maintain a $40 per ton price due to his market position.

The probability distribution shown above has a mode, the 'most likely' value, and a mean, the 'expected value'. The mode is $20, since it is the point which corresponds to the highest probability, and is that point which will be usually chosen when single value estimates are requested. The mean, or 'expected value', is a weighted average of the range of possibilities and is the summation of all the dollar values times the probability of each occurring. Thus in the above example the calculation is as follows:

$5 x .05 =. $0.25
$10 x .20 = $2.00
$20 x .40 = $8.00
$30 x .30 = $9.00
$40 x .05 = $2.00
1.00 $21.25 = expected value

If a single value must be used in place of the probability distribution then the expected value is the best point to use.

The analyst can build probability distributions for the other variables; in the case of a thermal electric power plant he may wish to consider the distributions of capital costs, operating costs, demand for electricity and the price range at which the product can be sold.

This building of probability distributions is one of the main benefits to be derived from risk analysis in that it forces the analyst to question the underlying assumptions for the values of each variable. This process gives greater insight into the determinants of the variables and should result in an investment analysis that is an accurate reflection of the future.

When the expected values of the variables have been calculated, the analyst completes the investment evaluation in the usual way (see Chapter 4).

An element which should be taken into account in decisions on projects in light of uncertainty is the flexibility allowed by the project to adjust to changing factor input prices. The best means of explaining this is by illustration. Establishment of a ferry transportation system such as that of B.C. Ferries offers a relatively great degree of flexibility in operating the system in the presence of changing prices. On the other hand, a hydroelectric dam offers somewhat less flexibility in adjusting the operating regime to changes in input prices since it basically locks in the technology current at the time of its construction. If flexibility is likely to be important in any actual cases, the analyst should reflect the varying degrees of flexibility by adjusting the probabilities associated with various possibilities in the calculation of the expected terminal value of net benefits. Thus, a project of average flexibility would receive no adjustment, a very flexible project would receive an increase in the probability associated with beneficial input price changes while a very inflexible project would receive an increase in the probability associated with adverse input price changes. Such adjustments should be limited to approximately 1% of the expected terminal value of net benefits of the project prior to any adjustments as described above. We shall have more to say about project design and expected input price changes in a later chapter.

3.6.4.2 Method 2

If a more careful evaluation is required either due to the size of the project or the degree of uncertainty, a more appropriate means of handling risk analysis is the detailed examination of various possible developments of the project. At a minimum, three possibilities should be analyzed - one in which prices move as expected, one in which prices move adversely and one in which prices move favorably.

The best means of working through this type of calculation is to deal with the net benefits of the project in each period separately. Net benefits in each period should be calculated on the assumption that prices are at their expected levels. In addition, the analyst should calculate estimates of net benefits on the basis of 'pessimistic' and 'optimistic' assumptions about prices. To form estimates of prices based on optimistic and pessimistic assumptions, one might assume that there is a probability of 0.33 that the price might be more and/or less favorable than its anticipated value.[1] After all relevant prices are dealt with in this manner, the period-by-period estimate of expected net benefits is calculated. The expected terminal value of the net benefit stream is then calculated in the usual way.[2]

3.6.5 A Note on the Meaning of Expected Value

The expected value of a variable is the mean of the probability distribution of values of the randomly distributed variable. The form of the probability distribution may take a variety of specifications, a common specification being the normal distribution which has certain useful properties. One must be careful to avoid confusion between the statistical definition of expected values and the colloquial use of that phrase. An example will help to clarify this point. If a six-sided die is tossed and one is told that one will receive as many dollars as shown on the die, what is the mathematical expectation (expected value) of the game. It's $3.50 (1 x 1/6 + 2 x 1/6 + 3 x 1/6 + 4 x 1/6 + 5 x 1/6 + 6 x 1/6). The actual outcome of the toss could be 1 dot or 6 dots (dollars). But, if the experiment were repeated a very large number of times, the average value of the many outcomes would be $3.50.

Thus, we would not be alarmed to find in retrospect that the actual terminal value of a project did not turn out to be equivalent to the expected terminal value of the project as calculated in anticipation of events. In fact, as the above example shows, we would be very surprised if the actual net terminal value equalled the expected net terminal value.

3.6.6 True Uncertainty (uninsurable Risk)

Uncertainty of the global variety, e.g., the state of the world in the nuclear age, certainly has the potential for drastically affecting the results of project appraisal. Short of doomsayers and other prophets of catastrophy, there is no systematic method of incorporating this type of uncertainty in project appraisal. Uncertainty is therefore best ignored in project evaluation.

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[1] Clearly an optimistic assumption requires that the term favorable means higher output prices and lower input prices, while the term unfavorable requires the reverse.

[2] See Chapter 4.

3.6.7 Summary

Several acceptable methods of risk analysis in project appraisal are recommended. The appropriate method in any particular circumstance depends upon the number of government projects, the size of the particular project, the availability of data to support analysis of this type, etc. Generally speaking, it is necessary to balance the cost of determining alternative outcomes against the usefulness of the knowledge gained from the analysis in relation to the above considerations. The larger the project with respect to, say, the gross provincial product, the more useful detailed analysis will be. On the basis of the theory of actuarial risk pooling, the more public projects there are, the lower the risk associated with that investment portfolio.

Even if it is known that a project is highly risky, this is not sufficient reason to forego the project. It is often true that higher risk projects are associated with higher payoffs and should be undertaken. The cost of evaluating the risk of a small project may often exceed the losses incurred if the project performs at less than the expected net terminal value.

GUIDELINE:

The following methods for risk analysis are recommended. As a rough criterion to determine which method is appropriate in particular circumstances, we recommend that Method 1 be used for projects with total construction expenditures in excess of 1/2 of 1 percent of the Gross Provincial Product for the year preceding that in which the analysis is conducted. Method 2 should be employed for projects with construction costs less than ½ of 1 percent of Gross Provincial Product.

Method 1. This method entails the use of expected values for the physical inputs and outputs of the project as well as the prices of the inputs and outputs. This information is used to calculate an expected net present value for the project.

Method 2. Implementing this method involves the development of several (a minimum of three) scenarios respecting alternative 'futures' for the project. 'Optimistic', 'pessimistic' and 'anticipated' assumptions as to future inputs, outputs and prices are developed. This information is used to construct estimates of expected net benefits on a period-by-period basis which then is converted to a net terminal value sum by compounding.

CHAPTER 4

DISCOUNT RATES, DISCOUNTING METHODS AND RANKING CRITERIA

4.1 The Discount Rate: Social Opportunity Cost (SOC) Versus Social Time Preference (STP)

4.1.1. Background and Definitions

The discount rate is one of the most important parameters used in benefit-cost analysis. Perhaps because of its importance it has been the subject of a continuing controversy on two fronts. The debate in the literature of public finance and public expenditures analysis has been concerned both with the theoretical problem of what it is that the discount rate is to measure - social time preference or social opportunity cost - as well as with the precise means of empirically estimating the value of the discount rate for a given society or economy under either of the two concepts.

It should be mentioned at the outset that it is theoretically possible for the rate of social time preference and the social opportunity cost of capital in an economy to be equivalent, although under a very restrictive set of conditions. By exploring for a moment the background for this statement, it is possible to both define the two terms and get an idea of the concepts behind them.

Individuals have a certain preference for present as against future consumption. This is individual time preference and can be expressed as a rate. If all individuals in society have the same preference for present consumption versus saving (for future consumption) one may take the representative individual's preference ordering over present and future consumption and speak of the time preference of society, or social time preference. Alternatively, if individuals have different consumption - saving preferences, one may conceive of some sort of weighting scheme such that it is possible to speak of the average time preference of a society. Thus, the concept of social time preference remains intact even in the presence of differing individual time preference. If individuals save (abstain from consumption) in the present, investors (probably business firms) can invest the funds productively at some positive rate of return. Assuming the set of conditions defining perfect competition[1] in an economy, the rate of return generated by the marginal (next) investment opportunity is the social opportunity cost of capital.

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[1] See any textbook in microeconomics for a definition of perfect competition.

If there were no income tax on businesses, if investors had perfect knowledge of investment opportunities, if individuals budgeted carefully so that the last dollar they saved returned sufficient income (consumption power) in the future so that the inconvenience of waiting to consume was exactly balanced with this increased income, and if individuals, governments and business firms could borrow and lend at the same rate of interest, the social rate of time preference would exactly equal the social opportunity cost of capital. Another way of stating this result is that marginal rates of return on investments in the private sector would be just sufficient to induce individuals to save just enough to undertake these investments.

Of course these restrictive conditions do not hold in most economies. The major causes of divergence are the existence of income and other taxation of the corporate sector, imperfect capital markets which lead to differential borrowing and lending rates for most businesses and all individuals, individual preferences which lead many individuals to conclude that the returns to saving are not sufficiently high and differential taxation of various classes of business (e.g., extractive versus manufacturing) and individuals (renters versus home owners). Economists and policy makers are therefore faced with a situation in which social rates of time preference diverge from the social opportunity cost of capital invested in private projects. This divergence set the stage for the debate over the appropriate concept (SOC versus STP) and measure to apply in evaluation of public projects.

4.1.2 Social Opportunity Cost[2]

Those who argue in favor of using a social opportunity cost rate of discount maintain that the use of any other discount rate in public project evaluation implies an inherently inefficient allocation of resources between present and future consumption (present saving). If capital invested in the private sector could return r percent[1] to the investor, it is detrimental to society's best interests (i.e., it is inefficient) to invest this capital in a public project which returns r^* where r^* is less than r. There are three important implications of this reasoning:

(i) The total amount of capital available for investment in a society is a given amount per unit time and is determined by past investment and the aggregation of individuals' preferences for present consumption as against saving.

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[1] This is a pre-tax rate of return. Where a public and a private project are to be compared, the pre-tax rate of return is the relevant rate for the public project.

[2] For purposes of this background discussion, we are assuming the existence of the restrictive set of conditions which defined the Standard Project of Chapter II.

(ii) The division of this given quantity of capital between investments in the public and private sector is determined by rates of return in the private sector as compared to discount rates employed (explicitly or implicitly) in public sector investment evaluations.[1]

(iii) Since different public projects have different mixes of productive inputs, the discount rate employed in public sector project evaluations will materially affect the character of public investments and, over time, the size of the capital stock in the public sector as against that in the private sector.

Clearly, the discount rate is a most important element in project evaluation for it assists in determining the distribution of production between the public and private sectors and the character of the capital stock in the public sector.

4.1.3 Social Time Preference

A thread of thought developed around the turn of this century by a well-known economist has become the basis for a line of thinking employed by present day economists and political theorists who argue in favor of a social time preference rate of discount to be used in public project evaluation.[2] Pigou's view, simply stated, is that individuals suffer from faulty long-term vision (they're myopic) in their consumption-saving decisions. He felt that individuals placed too much weight on the present and too little on the future to the detriment of generations yet unborn. Whereas future generations were materially affected by society's present-day decisions, they were, by definition, under-represented in the decision-making process. To correct this intergenerational equity problem, Pigou, and more recently Arthur Maass[1], Stephen Marglin[2], and others have favored using a lower rate of discount than is implied by the social opportunity cost. The effect of this lower discount rate, they argue, will be a bequest of greater capital stock (social infrastructure) than would have resulted using the social opportunity cost discount rate, ceteris paribus. Other things equal, more capital stock for future generations implies greater prosperity (as measured by per capita incomes) and the intergenerational equity problem is at least partially redressed.

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[1] Of course, investment is a dynamic process and it is strictly incorrect to speak of a given quantity of capital. It may be preferable to envisage a flow of funds directed by the discount rate into the two sectors. The rates of flow into each sector are influenced by the magnitude of the discount rate.

[2] Pigou, A.C., The Economics of Welfare, 4th ed., London, 1932.

The social opportunity cost versus social time preference as a basis for determination of the social discount rate ultimately boils down to a debate between efficiency versus equity as a basis for public policy formation (see Chapters 1 and 6). The social opportunity cost is an efficiency measure of the cost of productive resources whereas the social time preference rate concerns the distribution of income between the private and public sectors as well as between present and future generations. Use of the social time preference in project evaluation, however, obviously has efficiency implications. The degree to which intergenerational equity considerations should govern public policy formation can't even be determined at the political level. Politicians elected by the present members of society cannot determine what is best for future generations. Nor, for that matter, can politicians determine what future generations want without knowledge of their aggregated individual preference functions. This is clearly impossible. To the extent that the emerging ethic of the 'ecology movement' is indicative of the preferences of the future, a higher rather than lower discount rate may be indicated. Meanwhile, for practical considerations, analysis must proceed largely on the assumption that economic efficiency is the primary basis for determination of the discount rate.

GUIDELINE:

The discount rate to be used in evaluation of public sector investments in British Columbia has its basis in the social opportunity cost of capital. The social opportunity cost of capital is measured by pre-tax rates of return on capital invested in the private sector.

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[1] Maass, A., "Benefit-Cost Analysis: Its Relevance to Public Investment Decisions." Quarterly Journal of Economics, 1966.

[2] Marglin, S.A., "The Social Rate of Discount and the Optimal Rate of Investment." Quarterly Journal of Economics, February, 1963, 77, 95-112. Also see: Stephen A. Marglin, Public Investment Criteria: Studies in the Economic Development of India. George Allen and Unwin, London, 1967.

4.2 Measurement of the Social Opportunity Cost of Capital

Due to capital market imperfections, unequal risks associated with investments in different sectors of the economy, corporate income taxes affecting different sectors differentially and a variety of other circumstances, rates of return on investment in one sector may not be equivalent to rates of return in other sectors.

The solution to the practical problem of measuring the social opportunity cost of capital for a society in which rates of return on investment in the private sector vary from sector to sector has been suggested by several writers.[1] Basically the procedure suggested is the calculation of a weighted average private sector rate of return in which the weights are the proportions of total financing for the project(s) in question which are diverted from each sector of the economy. To illustrate the method, we reproduce one author's example here.[2] Assume there exists a two-sector economy with production taking place in both the consumer and the corporate sectors. Assume that the rates of return on investment (opportunity cost) for each of the sectors are 5% and 10% respectively. Assume that the resources to be employed in the proposed project would otherwise have been divided among the two sectors as follows:

consumers' goods production by consumer sector	20%
consumers' goods production by corporate sector	70%
producers' goods production by corporate sector	10%

Calcualtion of the weighted average discount rate may now proceed as follows:

$$[20/100] \times 5\% + [(10 + 70)/100] \times 10\% = 9\% .$$

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[1] See, for example, Charles W. Howe, Benefit-Cost Analysis for Water System Planning. American Geophysical Union, Washington, D.C., 1971; A.C. Harberger, "On Measuring the Social Opportunity Cost of Public Funds." in The Discount Rate in Public Investment Evaluation."; Conference Proceedings of the Committee on the Economics of Water Resources Development, Western Agricultural Economics Research Council, Denver, Colorado, December, 1968. Report No. 17. There are, of course, a number of other authorities suggesting use of this method.

[2] Baumol, "Analytical Problems in Policy Analysis." Public Expenditures and Policy Analysis, Havelman and Margolis, editors, p. 279-280.

Of course, in any actual project evaluation, investment resources could be diverted from a wide variety of productive sectors, thus compounding greatly the difficulty of obtaining the information required to perform the above calculation. In addition, it may be difficult or impossible for the analyst to identify from which sectors resources would flow (and in what proportion) in the event that the project is built. A further implication is that since different potential projects might pull resources in different proportions from different sectors, the calculation should be repeated for each project evaluation. While this represents the optimal procedure, in practice this is unlikely to be accomplished. In view of the impracticality of estimating a weighted average discount rate separately for each project, on the basis of previous work by others, we shall put together a method of obtaining a weighted average social opportunity cost for the typical British Columbia project.

4.2.1 Empirical Studies

The methodology of two studies which obtain estimates of the social opportunity cost of capital for Canada are reviewed in some detail in Appendix A. The earlier study by Reuber and Wonnacott[1] employs a 'borrowing model' approach which begins with a financial rate of interest to which several adjustments are made in order to arrive at a real rate of interest. The more recent study by Jenkins[2] employs the financial statements of 3-digit standard industrial classification industries to which a number of adjustments are made to transform accounting financial statements to consistency with economic definitions and concepts. The Jenkins study is preferred for a number of reasons. The methodology employed by Jenkins is precisely that which is required to estimate the social opportunity cost of capital. The Jenkins study also highlights the differential rates of investment productivity and taxation in each sector and therefore contains the raw material for calculation of a weighted average opportunity cost of capital as described above. Finally, the more recent data coverage and the greater sectoral detail are additional reasons for preferring the Jenkins study.

Table 1 following is reproduced from the results of Jenkins' work.

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[1] Reuber, G.L. and Wonnacott, R.J., The Cost of Capital in Canada - With Special Reference to Public Development of the Columbia River, Resources for the Future, Washington, D.C., 1961.

[2] Jenkins, Glenn P., "The Measurement of Rates of Return and Taxation from Private Capital in Canada", in Benefit-Cost and Policy Analysis. A.C. Harberger, et al, editors (Chicago: Aldine Company) 1972.

TABLE 1. RATES OF RETURN AND TAXATION FROM CAPITAL IN CANADA BY SECTOR (AVERAGE, 1965-1969)

	Industry	1 [d]Private Rate of Return Excluding Capital Gains and Losses	2 [e]Private Rate of Return Including Capital Gains and Losses	3 [f]Property Tax as a Percentage of Net Fixed Assets and Working Capital	4 [g]Income Tax as a Percentage of Net Fixed Assets and Working Capital	5 [h]Sales Taxes as a Percentage of Net Fixed Assets and Working Capital	6 [i]Cross Rate of Return Excluding Capital Gains and Losses and Sales Taxes	7 [j]Social Rate of Return Excluding Capital Gains and Losses Including Sales Tax
1.	Foods and Beverages	7.99	7.21	.79	5.10	15.78	13.88	29.66
	A. Food Industries	6.67	5.87	.77	3.49	.41	10.94	11.34
	B. Soft Drinks	10.82	9.91	.91	5.82	5.06	17.25	22.30
	C. Breweries and Wineries	11.57	10.88	.68	10.28	74.16	22.52	96.68
2.	Tobacco Products	6.96	6.66	.37	6.41	119.27	13.73	133.00
3.	Rubber Products	5.15	4.48	.41	3.31	2.54	8.86	11.41
4.	Leather Products	5.19	4.91	1.06	2.69	3.54	8.94	12.48
5.	Textile Mills	4.81	3.65	.51	2.31	1.40	7.62	9.01
6.	Knitting Mills	6.21	4.87	.84	3.09	5.62	10.14	15.76
7.	Clothing Industry	6.57	6.06	.83	2.99	4.47	10.44	14.92
8.	Wood Industry	6.98	5.79	.51	2.90	.14	10.39	10.53
9.	Furniture	6.62	5.95	1.26	2.75	4.61	10.63	15.23
10.	Pulp and Paper and Allied Industries	4.65	3.63	.56	2.22	.21	7.44	7.65
	A. Pulp and Paper Mills	4.56	3.17	.52	1.98	.11	7.07	7.17
	B. Paper Boxes and Convertors	6.73	5.69	1.07	5.26	1.29	13.06	14.34
11.	Printing and Publishing	9.49	8.76	.73	5.42	1.02	15.64	16.66
	A. Commercial Printing	8.28	7.57	.78	3.39	1.86	12.45	14.31
	B. Publishing	2.36	1.32	.11	1.54	.21	4.00	4.21
12.	Primary Metals	6.02	4.92	.23	2.29	.27	8.53	8.79}
13.	Metal Fabricating	6.51	6.10	.67	3.77	.66	10.96	11.62}
14.	Machinery Industries	9.10	8.77	.45	4.61	1.58	14.17	15.75
15.	Transportation Equipment	7.73	7.25	.59	5.39	9.34	13.71	23.04
	A. Aircraft and Parts	4.22	3.89	.40	.66	.92	5.29	6.20
	B. Motor Vehicles	11.45	10.59	.70	8.38	16.54	20.54	37.08
	C. Miscellaneous Transportation	4.05	3.63	.65	3.80	1.14	8.50	9.65
16.	Electrical Industries	6.37	5.82	.46	3.07	4.30	9.90	14.20
	A. Electrical Industrial Equipment	5.54	4.98	.73	2.77	1.27	9.04	10.32
	B. Other Electrical Products	7.03	6.43	.31	3.33	6.13	10.68	16.81
17.	Non-Metallic Mineral Products	6.09	5.06	.46	2.39	.50	8.95	9.44
18.	Petroleum and Coal Refineries	5.84	4.91	1.33	1.35	4.71	8.51	13.22
19.	Chemical Industries	6.33	5.39	.45	4.26	.91	11.03	11.94
20.	Miscellaneous Manufacturing	6.47	5.98	.72	5.10	3.32	12.29	15.61
21.	Total Manufacturing	6.45	5.53	.61	3.32	4.77	10.38	15.14
22.	Total Construction	6.54	6.24	.68	2.61		9.82	9.82
	A. Building Contractors	4.92	4.79	.81	2.12		7.84	7.84
	B. Highway and Bridge Construction	6.33	5.98	.41	2.76		9.50	9.50
23.	Total Transportation	2.62	.59	.82	1.06		4.50	4.50
	A. Air Transport	3.49	1.81	.36	.35		4.20	4.20
	B. Water Transport	1.78	-.28	.27	.58		2.64	2.64
	C. Railways	1.03	-1.00	.67	.90		2.60	2.60
	D. Truck Transport	9.08	7.67	3.24	2.71		15.03	15.03
	E. Pipelines	6.56	4.28	.64	1.92		9.12	9.12

	Industry	1 [d]Private Rate of Return Excluding Capital Gains and Losses	2 [e]Private Rate of Return Including Capital Gains and Losses	3 [f]Property Tax as a Percentage of Net Fixed Assets and Working Capital	4 [g]Income Tax as a Percentage of Net Fixed Assets and Working Capital	5 [h]Sales Taxes as a Percentage of Net Fixed Assets and Working Capital	6 [i]Gross Rate of Return Excluding Capital Gains and Losses and Sales Taxes	7 [j]Social Rate of Return Excluding Capital Gains and Losses Including Sales Tax
24.	Storage	4.09	4.14	1.33	1.18		6.59	6.50
	A. Grain Elevators	3.27	3.91	.62	7.01		4.89	4.85
	B. Storage and Warehouses	6.05	5.95	3.61	1.96		11.62	11.62
25.	Communications	6.94	5.25	.04	2.63	.48	10.40	10.88
	A. Radio and Television	5.71	4.56	.50	3.95		10.16	10.16
	B. Telephones	7.05	5.12	.67	2.53	.53	10.41	10.94
26.	Public Utilities	5.57	1.41	.91	1.78	.61	8.27	8.87
	A. Electrical Power	4.97	.69	.81	2.03	.65	7.76	8.44
	B. Gas Distribution	6.32	2.21	1.00	1.57	.58	8.89	9.47
27.	Wholesale Trade	7.73	7.57	.76	3.61	3.65	12.09	15.73
28.	Retail Trade	7.59	7.38	1.62	3.53	.44	12.73	13.17
29.	Total Finance, Insurance, and Real Estate	4.22	4.21	.23	.39		4.84	4.84
	A Trust Companies	4.81	4.81	.04	.34		5.19	5.19
	B. Mortgage and Loan Companies	5.16	5.17	.01	.09		5.27	5.27
	C. Banking	3.33	3.29	.02	.41		3.73	3.73
	D. Total Deposit Accepting Institutions	3.27	3.28	.02	.36		3.65	3.65
	E. Total Investment Companies	4.89	5.26	.04	.25		5.17	5.17
a* 29.	Total Finance, Insurance, and Real Estate	6.74	6.73	.93	1.57		9.16	9.16
	*A. Trust Companies	6.64	6.63	.48	4.05		11.16	11.16
	*B. Mortgage and Loan Companies	10.07	10.17	.12	2.12		12.41	12.41
	*C. Banking	8.57	8.31	.38	9.02		17.96	17.96
	*D. Total Deposit Accepting Institutions	7.51	7.55	.29	6.20		14.00	14.00
	*E. Total Investment Companies	6.10	6.10	.06	.33		6.48	6.48
30.	Total Services	9.88	9.83	1.46	2.24	.17	13.58	13.75
	A. Services to Business and Management	17.42	17.07	1.05	7.34		25.52	25.52
	B. Personal, etc., Services	9.43	9.53	1.46	1.65	.19	12.54	12.73
31.	Total Non-Manufacturing	6.25	5.31	.95	2.01	.39	9.21	9.71
32.	Mining	7.35	n.a.	.38	2.42		10.16	10.16
33.	Mineral Fuels	4.94	n.a.	.42	.80		6.18	6.19
	A. Mineral Products and Petroleum Refineries	5.34	n.a.	5.05	1.06	2.27	11.45	13.71
34.	Agriculture	2.65	5.30	.80	-.53		2.83	2.83
b** 34.	Agriculture	4.31	6.85	.88	-.81		4.48	4.43
35.	Rental Housing	5.32	7.04	2.58	nil		7.86	7.86
36.	Owner Occupied Housing	5.13	7.84	2.48	-.57		7.19	7.19
37.	Trade (Non-Corporate)	7.34	7.19	1.11	nil	2.27	8.47	10.74
c 38.	Total All Activities	5.82	n.a.	1.49	1.11	1.11	8.44	9.54

a. The rates of return and taxation in categories *29A through *29E for financial intermediaries are based on the value of equity in the sector and the private rates of return only include income accruing to the equity holders.

b. The rates for non-manufacturing exclude 29 but include *29 for financial intermediaries.

c. The rates of return for the total of all activities excludes categories 29 and 34 but includes *29 and **34.

d. (Table 3 ÷ Table 2) × 100 and averaged over the five years 1965-1969.

e. (/Table 3 + Table 4/ ÷ Table 2) × 100 and averaged over the five years 1965-1969.

f. (Table 5 ÷ Table 2) × 100 and averaged over the five years 1965-1969.

g. (Table 6 ÷ Table 2) × 100 and averaged over the five years 1965-1969.

h. (Table 7 ÷ Table 2) × 100 and averaged over the five years 1965-1969.

i. (/Table 3 + Table 5 + Table 6/ ÷ /Table 2/) × 100 and averaged over the five years 1965-1969.

j. (/Table 3 + Table 5 + Table 6 + Table 7/ ÷ /Table 2/) × 100 and averaged over the five years 1965-1969.

4.2.2 The Influence of Source of Funds on the Social Opportunity Cost of Capital

The discussion on the social opportunity cost of capital to this juncture has assumed that all funds potentially to be used in the public sector would be obtained through private capital markets by the flotation of some form of debt security. However, governments also have the option of raising additional revenue through increases in tax rates. Frequently one hears the argument that the social opportunity cost of capital depends upon how the capital is raised - by taxes or borrowing. According to consumer behavior theory, increased taxes decrease income levels by the amount of the tax thereby decreasing saving by the marginal propensity to save times the income reduction; consumption is changed by the marginal propensity to consume times the income change. Continuing the erroneous argument, the tax revenue raised by reducing consumption should be evaluated at the social time preference rate of discount (assumed to be lower than the social opportunity cost). This reasoning is incorrect basically because there is no reason to evaluate a dollar taken from income at anything less than the social opportunity cost in the private sector (where it could be invested at that rate). From this analysis we may conclude that no matter how funds are raised - by borrowing or taxation, their appropriate opportunity cost is the social opportunity cost in the private sector.[1]

GUIDELINE:

(i) For public project evaluation in British Columbia, there are several procedures available for determining the proper discount rate. If it can be determined what proportion of funds for a project are diverted from other potential investments in given sectors within the Province, these proportions should be used to weight the rate of return from the relevant sector as given in column 7 of Table 1. From this a weighted average rate of return can be calculated as in the above example.

(ii) If sectoral detail cannot be obtained, it is recommended that a discount rate of 10% be employed with rates of 8% and 12% used for sensitivity analysis. Discounting calculations using rates either higher or lower than those recommended above may be employed but should be in addition to calculations displayed according to the above recommended rates.

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[1] Mishan's discussion of the discount rate is highly recommended. It may require several readings to grasp his points securely but the time will have been well spent. See Mishan, Cost-Benefit Analysis, Chapters 30-32.

4.2.3 A Note about the Level of the Recommended Rates

Evidence supporting the rates recommended above abounds. The Jenkins study indicates that the social rate of return in manufacturing is an average of 15.1 percent. The average rate for non-manufacturing was 9.7 percent yielding an average rate for all activities of 9.5 percent.[1]

In testimony before the Joint Economic Committee of the U.S. Congress, Dr. John V. Krutilla defended his use of a 9 percent discount rate by citing the testimony and research of fellow economists.[2] Professor Otto Eckstein appeared before the same Committee in 1968 and testified to the effect that the social opportunity cost of capital was of the order of 8 percent. Professor A.C. Harberger testified that something on the order of 10.7 percent was appropriate and was emphatic about a range of 2 percentage points above and below 10.7 percent, i.e., 8.7 percent and 12.7 percent. Professor Stockfish testified before the same Committee in September 1967 that he had developed an estimate of 13.5 percent which he subsequently revised down to 10.4 percent. It is to be noted that these people are eminent authorities who have spent their careers in the economics of public finance and public policy. It should also be noted that this testimony took place in the late 1960's in the United States - a country with traditionally lower interest rates than in Canada.

On the basis of the testimony reported here supported by the Canadian study also reported above, along with other observations made herein, the recommended rates of discount seem very reasonable.

Finally, it is important to note that the recommended rates are real, inflation-free rates to be used in studies employing current real-dollar estimates of benefits and costs.

4.2.4 Implications of Employing the Recommended Rates

It is not to be thought that the 8 - 10 - 12 percent discount rates are recommended in a light-hearted fashion. Considerable effort has been made to locate and obtain sufficient data and information to provide a basis for making a decision on this matter. The available evidence relevant for Canada has been reported and footnoted herein.[3]

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[1] Ibid., p. 225.

[2] Testimony of J.V. Krutilla before the Subcommittee on Economy in Government of the Joint Economic Committee, mimeo.

[3] Since the drafting of this section, the Planning Branch of the Treasury Board Secretariat has published a benefit-cost guide. The discount rate recommendation of the Treasury Board is 10% with 5% and 15% sensitivity bounds.

Clearly, the major implication of the use of the recommended rates is that capital will now have to carry its weight. What is meant by this is, of course, that capital intensive projects (relatively speaking) will have to generate a higher relative rate of return than less capital intensive projects in order to offset the higher 'shadow price' of capital and thereby still appear favorable by the criteria set out above and below.

A further implication is that use of these rates over a long span of time will imply less capital stock in the public sector than if lower discount rates were used, other things equal. Whether this is a 'good' or a 'bad' is a political/philosophical question which can be debated but is not subject to analysis.

It is often suggested that use of 'high' discount rates will bias decisions in favor of use of non-renewable over renewable resources, particularly in the energy field. This does not necessarily follow. In particular, it is often suggested that thermal-electric projects based on fossil fuels will appear more favorable than hydro-electric projects. However, if the capital employed in both projects bears the same opportunity cost, if appropriate opportunity cost 'shadow prices' are applied to the fossil fuels and if the capital employed in extracting the fossil fuels (generally a capital intensive process) bears the appropriate rate of discount, then there should be no such bias. If decisions made on this basis still prefer thermal-electric projects over hydro-electric, then one must recognize that capital too is a scarce resource and that, other things equal, the former project uses less of the relatively more scarce resource.

4.3 Ranking Criteria for Investment Decisions

Investment criteria provide the means of assessing the desirability of investing in projects by enumerating and evaluating all relevant costs and returns. Acceptable investment criteria must reflect all benefits and costs attributable to the investment during its life and also weigh the timing of these benefits and costs since those which occur earliest are more significant than those which occur later, other things equal.

The discussion of ranking criteria will review, compare and contrast the more frequently proposed criteria - net present value, internal rate of return and benefit-cost ratio. The problems encountered in use of these criteria will be outlined and illustrated where appropriate. Finally, from this background discussion, a particular investment criterion will be developed and recommended for use in project evaluation in British Columbia.

4.3.1 Simple Investment Criteria

A number of simple investment criteria have been devised largely for application in private business investment decision-making. While these criteria might be appropriate in certain such applications, they are not considered applicable in the context of public investment decision-making in British Columbia primarily because they do not account for the timing of the benefits and costs (receipts and expenditures in a private context). For completeness, we briefly mention these criteria but do not discuss them at length.

The cut-off period criterion is the crudest of the methods employed in industry. A period of time is arbitrarily chosen during which all outlays on a project must be recovered. Any investment project not meeting this criterion is dropped from further consideration. The pay-off period may be used to rank investment options, the ranking being based on the number of years required to recover all outlays on each project. The pay-off period rate of return is derived from the pay-off period and is obtained simply by dividing 100 by the pay-off period. The net average rate of return is calculated by obtaining the algebraic sum of receipts and expenditures and dividing this result by the number of periods used to accumulate receipts and expenditures.

Aside from the time dimension, there are other problems associated with use of the above criteria. For a more complete explanation see E.J. Mishan[1] or any reference text on industrial investment analysis.

4.3.2 Net Present Value

The net present discounted value or net present value (NPV) of an investment is calculated by determining the net flow from the investment (benefits minus costs) for each time period then weighting the resulting net by the factor $^1/(1 + r)^t$ where r is the appropriate discount rate and t refers to the time period associated with the net flow. Consider the following example:

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[1] Mishan, E.J., p. 185 and passim.

	PERIOD			
	1	2	3	4
PROJECT A				
BENEFITS	0	0	40	60
COSTS	30	30	5	5
NET BENEFITS	-30	-30	35	55
PROJECT B				
BENEFITS	0	0	40	60
COSTS	15	15	20	20
NET BENEFITS	-15	-15	20	40

The net present value of project A is calculated by solving the following equation, assuming a 10 percent rate of discount.

$$NPV_A = \frac{-30}{(1 + .10)^0} + \frac{-30}{(1 + .10)^1} + \frac{35}{(1 + .10)^2} + \frac{55}{(1 + .10)^3} = 12.98.$$

NPV_B is calculated similarly.

$$NPV_B = \frac{-15}{(1 + .10)^0} + \frac{-15}{(1 + .10)^1} + \frac{20}{(1 + .10)^2} + \frac{40}{(1 + .10)^3} = 17.94.$$

According to the above, if the projects were to be ranked by their NPV, project B would be preferred to A. Alternatively, at a discount rate of 5 percent the NPV of project A is 20.69 whereas that of project B is 23.40. Using NPV to rank the projects and assuming a 5 percent rate of discount, the project ranking is the same as that obtained using NPV and assuming a 10 percent discount rate. However, the gap between the two NPV's has narrowed. This suggests that further lowering of the discount rate will, at some point, result in a reversal of the project rankings.[1] Notice also that this result obtains even though the total benefits and total costs for both the projects are the same. Clearly, since the timing and magnitude of the benefits is the same for both projects, the timing of the costs is what is affecting the NPV when using the different discount rates.

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[1] In the example shown both projects have a NPV of 30 using a zero discount rate.

4.3.3 The Benefit-Cost Ratio

The same information required to calculate the NPV of a project can also be employed to calculate the benefit-cost ratio except that now one applies the discount factor to the total benefit and cost estimates. Referring back to the example of the last section one calculates the value of

$$\sum_{t=1}^{4} B_t \left[\frac{1}{(1+r)^t}\right] \qquad \text{and}$$

$$\sum_{t=1}^{4} C_t \left[\frac{1}{(1+r)^t}\right]$$

where B_t and C_t refer to the benefits and costs for each project occurring in each period. Performing the calculation for each project at both the 10 percent and 5 percent discount rates we have, respectively,

	PROJECT A	PROJECT B
DISCOUNT RATE	10%	10%
DISCOUNTED TOTAL BENEFITS	78.14	78.14
DISCOUNTED TOTAL COSTS	65.16	60.20
BENEFIT-COST RATIO	1.20:1	1.30:1
DISCOUNT RATE	5%	5%
DISCOUNTED TOTAL BENEFITS	88.11	88.11
DISCOUNTED TOTAL COSTS	67.43	64.71
BENEFIT-COST RATIO	1.31:1	1.36:1

Ranking inconsistencies resulting from each of the four criteria we review can occur although the above examples have not exemplified this. These inconsistencies result from implicit assumptions necessary to the proper use of the methods but which do not hold true in the cases where inconsistencies arise. After reviewing the internal rate of return criteria, we shall explore the necessary conditions for using each of the criteria and then suggest a normalization criterion for removing the cause of inconsistent rankings.

4.3.4 Excess Benefit Over Cost Ratio

A further means of arraying investment projects is by the ratio of present value of total benefits minus present value of total costs to present value of total costs. Referring back to the example developed above and assuming a 10 percent rate of discount the projects would be ranked, B preferred to A as shown by the table below.

	PROJECT A	PROJECT B
(1) DISCOUNTED TOTAL BENEFITS MINUS DISCOUNTED TOTAL COSTS	(78.14- 65.16)	(78.14- 60.20)
(2) ÷ DISCOUNTED TOTAL COSTS	65.16	60.20
RATIO OF (1) : (2)	0.24	0.30

The three ranking methods presented above are all variations of the present value criterion. Which method is preferable will be the subject of a following section. However, before comparing and contrasting the criteria and their means of implementation, it is necessary to introduce another major investment criterion.

4.3.5 Internal Rate of Return

The internal rate of return of a project is that rate of discount which equalizes the present discounted value of benefits and the present discounted value of costs of a project. Another method of defining the internal rate of return is that rate of discount which sets the NPV of the project to zero. In private industry this criterion is normally referred to as the discounted cash flow method. In social benefit-cost analysis, real flows are considered in addition to cash outlays and receipts. The internal rate of return can be solved by finding the solution to IRR in the following equation

$$\sum_{t=0}^{t} \left[\frac{B_t}{(1 + IRR)^t} \right] = 0$$

where B_t is the net benefit of the proposed investment at t.

Aside from the computational difficulty associated with the internal rate-of-return (unless one has a computer program which solves for IRR using various values of B_t and t), there is an additional operational difficulty involved with this method. The solution for IRR involves taking roots of a polynomial expression. In a simple 2-period case, the equation will have two roots - two values for IRR, the internal rate of return. In the more general n-period case ($n > 2$), there will be n-1 roots, each qualifying as a rate of return (excluding negative roots).

4.3.6 Comparison of the Ranking Criteria

The computational convenience of the present discounted value criterion and the multiple root problem associated with the internal rate of return criterion leads to a preference for the present discounted value (NPV) criterion. However, we have seen that all the methods of implementing this preferred criterion, i.e., net present value, ratio of discounted benefits to discounted costs (benefit-cost ratio) and excess benefit over cost ratio, can give inconsistent rankings under certain circumstances. These inconsistencies are in addition to those which can result from comparing projects using any of the above criteria with the internal rate-of-return. It was suggested earlier that there were particular causes of these inconsistencies and it is now necessary to amplify this comment.

Necessary conditions for a consistent ranking by each of the criteria are:[1]

a. The reinvestment opportunities open to the benefits of each project must be made explicit and fully utilized in the evaluation.

b. The projects must have a common outlay as reckoned at some point in time.

c. The projects must have a common investment period.

Mishan proves that these three conditions, taken together are sufficient conditions as well. If these conditions are violated in any project appraisal, then the project ranking produced by the criteria outlined above may be inconsistent.

The cause of inconsistent rankings given by the different criteria is attributable to the fact that the normal application of the methods requires implicit assumptions which break one or more of the necessary conditions for a unique ranking. For example, the internal rate of return criterion implicitly assumes that the benefits generated by the investment can be reinvested at a rate equivalent to the internal rate of return of the project. If this is not true, an inconsistent ranking will result. In addition, the internal rate of return criterion also assumes that all the investments evaluated by it are of equal investment period. This may be a further cause for non-unique rankings. The benefit-cost ratio assumes that all projects evaluated by it are of equal scale or size of outlay. If this is not true of a particular case, then this assumption is equivalent to assuming that the smaller project may be replicated by other projects each of which generates a benefit-cost ratio equivalent to the project in question.

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[1] Ibid., p. 236

Since there is really no strong objective means of establishing a preference for one criterion above the others outside of the several comments made above on the internal rate-of-return, it is important to establish a procedure for overcoming the inconsistent ranking problem. Fortunately, such a procedure has been developed by Mishan[1] and is based on the above necessary conditions. We proceed to a review of this procedure.

4.3.7 A Normalizing Procedure for Ranking Projects

The procedure for normalizing a set of projects so that valid and consistent comparisons can be made with any criterion is based upon ensuring that the above three necessary and sufficient conditions are not violated in the process of project evaluation.

The first step (adjustment A) is to ensure that all projects have a common outlay. Performing this step in the normalization is sufficient to establish a consistent ranking between the benefit-cost ratio and excess benefit-over-cost ratio version of the NPV.

In establishing a common outlay for all the alternatives, it will be necessary, in most circumstances, to adopt the outlay associated with the largest project. This will be the case unless all the alternatives are divisible, i.e., that the largest projects cán be scaled down to equal the outlay of the smallest project or the smallest projects can be scaled up to equal the outlay associated with the largest project. In general, this will not be true and it should not be assumed unless actual circumstances warrant it. For all projects except the largest, there will be excess funds not needed for putting the smaller projects in place. These excess funds should be dealt with by assuming that they will be placed in investments in the private sector and there will earn the social opportunity cost rate of discount, for our purposes, approximately 10 percent. Thus for example, assume there are three projects, A, B and C which are divisible and which cost \$20 million, \$13 million and \$8 million, respectively. Project A's outlay is adopted as common and projects B and C have \$7 million and \$12 million, respectively, in excess funds not required for project construction. These excess funds should be dealt with in the project appraisal by showing them as an outlay. The benefits they generate in the private sector in which they earn the social opportunity cost rate of discount are shown among total benefits of the project. Having made this adjustment, any of the ranking criteria based on present discounted values, i.e., net present value, discounted benefit-cost ratio and excess benefit over cost ratio will give a consistent project ranking.

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[1] Ibid., chapters 35, 36

However, if the internal rate of return criterion were employed to rank the projects, inconsistencies would still arise. Therefore, further adjustments are required. Referring back to the necessary and sufficient conditions for consistent ranking, we recall that one condition required that reinvestment opportunities be made explicit and employed in the analysis. This adjustment may require one or all of the following calculations (adjustments B):

i. Project benefits which may be reinvested at a higher rate of return than the social opportunity cost rate of discount should be included among the project benefits at the higher rate of return. The term project benefits refers to the benefits which result from the investment project itself, exclusive of the benefits attributed to the project under normalization adjustment A.

ii. Project benefits accruing should never be reinvested at a rate below the social opportunity cost discount rate, i.e., 10 percent for British Columbia.

iii. Any project benefits which are consumed when they accrue should be evaluated at the social time preference rate of discount.

iv. In situations in which project benefits do not accrue in cash terms or in which political constraints will not allow reinvestment, the project benefits should be assumed to have been consumed.

The third and fourth adjustments above present a technical problem since we do not know the social time preference rate of discount. As a proxy measure for this parameter, the real rate of interest on riskless government bonds reported in the Reuber and Wonnacott study is suggested. This rate, currently approximately 9%, could be regarded as an upper bound on the time preference of society since, by its behaviour, society elected to purchase the bonds by reducing current consumption. Perhaps the 'true' social time preference is lower but without any other basis for selection, the interest rate on government bonds is suggested.

Finally, it is necessary to adjust the projects for variations in lengths of investment period (adjustment C). Basically, any length may be adopted provided that a length longer than that used for evaluation would not result in ranking reversal. As a practical matter, in order to ease the computational burden, it is suggested that the shortest investment period of any of the projects being compared be adopted as the common period.

The final major change in procedure from more traditional project evaluation procedures is that the technique of compounding gross benefit and total cost streams forward to the terminal date is employed. The rate at which the compounding is to take place is the social opportunity cost rate of discount. It will be seen in the example to follow that the compounding procedure aids in effecting the normalization procedure by explicitly including reinvestment opportunities for the benefits of each project. Use of compounding also implies that the investment criterion employed will be based on compounded, or terminal values of benefits and costs. If TV(B) and TV(C) signify terminal values of benefits and costs respectively, the appropriate investment criterion for admissability is $(TV(B) - TV(C)) > 0$. Ranking should be done on the basis of $(TV(B) - TV(C))$.

4.3.8 An Example of the Normalization Procedure

The example presented below is taken from that provided by Mishan.[1] We use the compounding method and assume a discount rate of 20%.

Assume a set of projects A, B and C each with the outlays and benefits as given in the following table. Costs are designated as negative benefits and are preceded with minus signs.

PROJECT	TIME PERIOD			
	t_0	t_1	t_2	t_3
A	-20	15	16	-
B	-100	-	-	160
C	-45	351	-402	-

If the capital available for investment is at least as large as 100, we may adapt this as the common outlay for performing adjustment A of the normalization. Project A must then be subjected to design analysis. Can it be scaled up by a factor of five? Or can it be replicated three times over? Answers to these questions must be obtained. If there is no opportunity for increasing the scale and if the market for the project output can absorb only one investment of this size and type, then 80 must be assumed to be invested in the private sector at the opportunity cost of capital in that sector. For simplicity, assume that project A can be scaled up to absorb an outlay of 100. The new figures for benefits and costs of project A are then - 100, 75, 80, --, --.

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[1] Ibid., p. 247 and passim.

For project B we assume a specific reinvestment opportunity at t_3, which returns a net of 18 at t_4. The figures for project B are then -100, --, --, 160, 18. Project C we shall also assume can be scaled down to an outlay of 100 at t_0. To determine the scaling factor, we sum 45 and 402 x $\frac{1}{(1 + .2)^2}$ and divide 100 by the sum. The result is 0.31. We then multiply the project C figures through by the factor 0.31. The normalized investment flows appear as in the Table 2 below.

Table 2: Project Evaluation
Using the TV(B) - TV(C) Criterion

Project	Time Period t_0	t_1	t_2	t_3	t_4	(B) Compounded Benefits	(C) Compounded Costs	(B-C)	(B-C)/C	IRR
A	-100	75	80	-	-	244.8	207.4	37.4	37.4/207.4	251.1%
B	-100	-	-	160	18	210.0	207.4	2.6	2.6/207.4	20.4%
C	-14	108.8	-124.62	-	-	188.0	207.4	-19.4	-19/207.4	17.2%

Using a 20% rate of discount, we may now calculate the terminal value of benefits and the terminal value of costs for each of the projects. These figures are given by the columns headed B and C, respectively, in Table 2 and are calculated as follows.

The terminal value at t_4 of the outlays on all the projects is the same. The result of the calculation for the A project is $100 \times (1 + .2)^4 = 207.4$. All other projects would have a terminal outlay value of 207.4 since we normalized the projects for this value.

The terminal value of the benefit stream for project A is the result of $75\ (1 + .2)^3 + 80\ (1 + .2)^2 = 244.8$. The terminal value of the B stream is given by $160\ (1 + .2)^1 + 18\ (1 + .2)^0 = 210.0$. Project C's terminal benefit value is $108.8\ (1 + .2)^3 = 188$. In these calculations, note that the compounding procedure automatically applies the assumed reinvestment rate of 20% to the benefits. The alternative procedure of discounting to a present value would require different handling with more computation.

Having calculated the compounded benefits and costs of each project, the terminal value of net benefit (TV(B) - TV(C)) and excess terminal value of net benefit over cost $\frac{TV(B) - TV(C)}{TV(C)}$ criteria may be applied directly. Ranking of the projects by these criteria is B, A, C with C being inadmissable, i.e., its net compounded terminal benefit value is negative.

The simplest criterion to apply is the excess terminal benefit criterion (TV(B) - TV(C)). Using $\frac{TV(B) - TV(C)}{TV(C)}$ adds nothing new to the analysis since the ranking is the same in both cases. It should be noted that present discounted value could be calculated from B and C in Table 2 above, simply by applying the discount factor $^1/(1 + r)^t$ where r is the social opportunity cost rate of discount and t is the number of periods over which discounting takes place. Again, however, this adds nothing since the ranking by any present value criterion is the same as the ranking by the terminal (TV(B) - TV(C)) value.[1]

The values of the internal rate of return presented in Table 2 above were calculated in a manner somewhat different from the usual interest rate of return calculation. The difference is this: rather than discounting the benefits occurring each period by the factor $^1/(1 + IRR)^t$ where the meaning of IRR is obvious and t is time, the compounded value of the benefits, B from Table 2 is multiplied by the factor $^1/(1 + IRR)^t$ and set equal to the initial outlay. Thus, instead of solving

$$\frac{75}{(1 + IRR)} + \frac{80}{(1 + IRR)^2} = 100$$

for IRR of project A we solve

$$\frac{75\ (1 + .2)^3 + 80\ (1 + .2)^2}{(1 + IRR)^4} = 100$$

The resulting IRR has only one value and is interpreted as an average rate of return.

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[1] See Appendix B for an example.

GUIDELINES ON PROJECT NORMALIZATION AND RANKING CRITERIA

It is recommended that the following procedures be employed in ranking projects in British Columbia:

i. The normalization procedure established above should be followed. This requires explicit recognition of reinvestment opportunities, in addition to developing common outlays and common investment periods for all projects to be compared with one another.

ii. Unless a specific reinvestment opportunity is open to the project benefits of a particular project (and unless) this opportunity earns more than the social opportunity cost of capital in B.C. (10%), then all reinvestment is to take place at this social opportunity cost rate.

iii. Project benefits consumed when they accrue or constrained from reinvestment by government policy, should be compounded forward at a rate which approximates the riskless government bond rate - 9%.

iv. The recommended ranking criterion is TV(B) - TV(C), although any of the ranking criteria discussed above may be employed after the normalization is performed.

CHAPTER 5

OPTIMIZING THE SELECTED PROJECTS

5.1 Introduction

As emphasized in chapter 1, benefit-cost analysis is most properly used in a comparative context wherein a range of different methods are available to supply a product or service. For example, in generation of electrical energy the project analyst should consider the traditional methods of hydroelectric and thermalelectric generation, but in addition should also consider the less traditional methods of nuclear, geothermal and perhaps even wind or tidal generation. The procedures and guidelines for evaluating structural alternatives for meeting the objective have been the subject of the previous chapters. Another class of structural alternative is a change of design, scale, timing and sequencing of any of the structural alternatives such as mentioned above. The topic of the present chapter is development of the methods of optimizing projects by consideration of the design, scale, timing and sequencing of the project(s) available for consideration.

5.2 Structural and Non-Structural Alternatives

Before launching the discussion of project optimization a few comments on consideration of non-structural alternatives are in order. Non-structural alternatives are defined as those which do not require additional physical facilities construction in order to meet the objective. For example, in the electrical energy generation field, pricing could be considered a non-structural alternative. Alterations to the pricing structure could lower the total demand or its temporal composition. This could have the effect of delaying or eliminating the requirement for the project being considered. A flood control project consisting of dikes, canals, etc. has the non-structural alternatives of flood insurance, flood plain zoning and flood proofing of buildings which should be considered in addition to the structural alternatives. Bringing these alternatives into direct comparison with the structural alternatives may well indicate that non-structural alternatives are the most efficient means of meeting the objective in terms of the criterion laid out in chapter 4.

The inclusion of non-structural alternatives implies that in instances where there are such non-structural alternatives the analyst may be considering private alternatives to public projects.

The costs of a flood insurance program, for example, might be borne by individual property owners in the flood plain area. Since the viewpoint remains unchanged in considering private alternatives, no changes in the procedures or guidelines developed above or below are required.

GUIDELINE:

Where non-structural alternatives are available, these must be included among the range of options to be considered in the analysis of means of meeting the objective.

5.3 Optimizing Project Design and Scale

5.3.1 Introduction

Evaluation of alternatives carried to this stage of analysis may well have resulted in the identification of one or more alternatives which look particularly attractive through all stages. Or, possibly there may have been only one or two alternatives available when the analysis began. In any case, more detailed project design and costing will be required in order to select the optimum project type. A re-examination of the benefits generated by a redesigned project is also required.[1]

5.3.2 Optimizing Scale for the Non-Staged Project

Capital projects are typically very "lumpy". Some projects may, however, offer the possibility of staged development whereas others may not. The rules for determining optimum scale will be equivalent for both types of projects but with a project requiring staging there are additional considerations to take into account.

A non-staged capital project is one which achieves its designed capacity upon commencement of operations without any opportunity for later expansion. The rule to be employed in this circumstance is a straightforward application of the marginality rules of economics. If the total benefits and total costs of a project can be expressed as being dependent upon the size of the project then marginal benefits and marginal costs are the additions to total benefits and costs caused by an increase in the size of the project. Since we are dealinq with time streams of benefits and costs it is necessary to put the various time streams on a common footing. If we employ the compounding procedure recommended in the previous chapter and refer to TV(B) and TV(C) as terminal values of total benefits and costs, respectively, the scale optimizing rule is

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[1] Howe, Charles W. Benefit-Cost Analysis for Water System Planning, American Geophysical Union, Washington, D.C., 1971. Much of the material in this and the following chapter is derived from Howe, chatper 6.

$$MTV(B)_S = MTV\ (C)\ _S$$

in which M stands for marginal and S refers to a particular project size. The variable S is likely to be discrete which means that the MTV(B) and MTV(C) variables are also discrete. The analyst should select a value of S which reflects his hunch as to that S-value which equates MTV(B) and MTV(C). Values of S which bracket the hunch value of S (one higher and one lower) should be used to calculate MTV(B) and MTV(C) and thereby confirm or refute the analyst's hunch that he has chosen the appropriate S-value. If size has more than one dimension the rule stated above must be applied to each dimension.

The rule developed above is to be applied to a project considered singly. If a series of projects are being considered, all of which will be constructed, the benefit-cost analysis is undertaken for the purpose of ranking the projects to determine the optimal sequence of project development. In this situation a different rule over-rides the rule stated above. If the objective is to maximize the net benefits of the sequence of projects and if the projects are ranked according to terminal value of net benefits, the following rule should be applied

$$MTV(NB)^1 = MTV(NB)^2 = \ldots\ldots. = MTV(NB)^N$$

where NB signifies net benefits ($TV(B)_S - TV(C)_S$) and the superscripts N refer to the projects. It is understood that changes in MTV(NB) are brought about by changes in S. Application of this rule will insure that the net benefits of the sequence of projects is maximized.

GUIDELINE:

The rule for determining the optimal size of a single project should be to optimize all dimensions of the size variable (e.g., height of dam, area of reservoir, length of penstocks, etc.). This rule is:

$$MTV(B)_S = MTV(C)_S$$

For a sequence of projects, all of which will be undertaken the rule is:

$$MTV(NB)^1 = MTV(NB)^2 = \ldots\ldots\ldots = MTV(NB)^N$$

5.3.3 Optimizing Scale for a Staged Project

A project may be divisible in the sense that its output may be expanded by additions to capacity as demand grows over time. An example of this type of staging opportunity is the installation of additional generators in a hydroelectric facility. Given knowledge of the growth path of demand for the proposed project's output, the relationship of cost to size of the total facility and at each of its stages and knowledge of certain technical aspects of the problem, the question is to determine the optimal size and timing for each increment in the project.

In attacking the problem the analyst is faced with three conflicting sets of circumstances:

i) Economies of scale may frequently be present. Thus, increasing project size may be desirable on these grounds.

ii) Given the pattern of demand and assuming that the facility is built to meet some future demand level, the larger the facility the larger the cost of excess capacity in the project.

iii) It may frequently be desirable to maintain flexibility so as to make adjustments to changes in demand, general economic circumstances, etc. The general nature of the problem then is to achieve the optimal balance between the added costs of excess capacity resulting from the addition of increments to the project and the lower costs associated with economies of scale.

economies.[1] Rather than review this work in detail the reader is referred to it as the need arises.

One rule which can be applied in a fairly wide variety of cases is the following. If[2]

i) the costs of indivisible projects or increments are independent,

ii) marginal benefits do not increase with the scale of the project but do increase over time,

iii) construction periods can be ignored, and

iv) the shadow price of capital reflects the appropriate opportunity cost.

then the optimal scheduling results can be achieved by starting each project or increment for construction the first time the project shows a positive terminal value, with the terminal value of benefits always computed on the (incorrect) assumption that the then current benefit rate will continue indefinitely.

The most stringent of the above conditions is the requirement that the cost of indivisible additions to a project are independent. In most projects cost independence will not be complete but will be a matter of degree varying from one case to another. The analyst will accordingly be required to make a judgmental decision as to whether the degree of cost independence in the particular project(s) he is working with is sufficient to break the condition.

The important point to take away from this discussion is that naive application of the criterion recommended in chapter 4, i.e., terminal value of net benefits may not only result in sub-optimal outcomes in relation to the project's potential but may indeed give the wrong answer with respect to that project. Marglin develops an example in which the application of the investment criterion in a 'to build or not to build' sense results in the 'rejection' of the project for present construction but 'acceptance' of the project for construction five years hence when the optimal decision is, in fact, to delay construction for another fifteen years.[1] The example is an extreme case but illustrates the possible errors which can be caused by simplistic application of the investment criterion without consideration of the dynamic nature of investment.

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[1] Alan S. Manne,"Capacity Expansion and Probabilistic Growth", Econometrica Vol. 29 No. 4(October 1961) pp. 632-649.

[2] Marglin, p. 78.

In practical terms it may not always be possible to carry the timing of investments to their optimal point. Other considerations such as the perceived need for the project output may force earlier construction than dictated by optimality rules. Nevertheless, whether or not optimality rules are used to determine actual construction schedules the project evaluation should include analysis of optimal construction timing.

GUIDELINE:

An analysis of the optimal timing of project construction should accompany the project evaluation. At a minimum this analysis should contain the results of a number of trial and error calculations of the terminal value of net benefits reckoned at the same terminal date assuming a number of different starting dates. More detailed analysis following that developed by Marglin[2] or Manne[3] may be employed as an alternative to the above.

5.5. Pricing the Output of Public Projects

5.5.1. Relationship Between Pricing and Investment Decisions

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[1] Ibid., p. 77.

[2] Marglin, Supra, p. 77.

[3] Manne, Infra.

Investment decision making and the pricing of the output of the investments are such closely related issues that it would appear unnecessary to state the obvious.[1] Yet in practice, pricing is a commonly neglected aspect of investment decision making. In these Guidelines the pricing question will be discussed primarily from the angle of the issues and implications of pricing to achieve certain given objectives. The engineering economics of the project itself (size, scale economies, etc.) will affect the pricing of the output from the project or system and must therefore be part and parcel of this discussion. Inasmuch as the price of the output directly affects the quantity of output demanded per time period as well as the growth of demand over time, the scale and timing of the project should be considered simultaneously with the output pricing. Lack of consideration of pricing can result in project planning being 'out of phase' with the actual course of events as the project is used; e.g., output capacity of the project may become fully committed earlier than planned, or vice versa. Therefore, pricing the output of a public project should be viewed as an aid to achieving a properly planned and successful public project.

5.5.2. Pricing Decisions In Imperfect Markets

The efficiency pricing rule of market price equal to marginal social cost of production which follows from general equilibrium and welfare economics holds when all markets are perfect. This rule gives a context to the term efficiency, i.e., and optium allocation of productive resources in all markets such that any other allocation will result in a lower level of welfare for society.

The Canadian economy does not meet the economist's ideal perfect market in most sectors. In fact, it would be exceedingly difficult to locate a sector in which markets were substantially perfect in this sense. Question then arises as to the degree to which we may rely on the efficiency pricing rule even if we wanted to. Important work along these lines has been done by Lipsey and Lancaster.[2] These researchers found that if prices were in excess of marginal costs in one market by say, k, percent, general economic equilibrium (and the highest attainable level of welfare) could be restored by 'correcting' prices in all other markets by raising them above marginal costs by k percent. The solution to the one imperfect market case is simple enough. However, most markets are imperfect to varying degrees. Therefore, attempts to follow the marginal cost pricing rule in one market may or may not be appropriate. The only means of determining a 'correct' marginal cost price for that market is to determine 'correct' prices for all other markets - practically speaking, an impossible task. While 'fine tuning' of marginal cost pricing to the theoretical ideal is an impossibly large task, some progress towards improving resource allocation can be made by rough and ready pricing schemes which distinguish between marginal costs of operating the capacity in place and the marginal costs of large additions to new capacity. Generally speaking, if society suceeds in building its best projects first (best projects are least cost projects) we should expect that costs of new source development will be increasing. In section 5.5.4. below an outline of a pricing scheme which makes the distinction between marginal capacity cost and marginal operating cost is laid out.

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[1] In private industry it would be considered unthinkable not to accord pricing analysis and market surveys equal status with manufacturing and technology considerations.

[2] Lipsey, Richard G. and Kelvin J. Lancaster, "The General Theory of Second Best", Review of Economic Studies, 1951.

5.5.3. Objectives of Pricing

Fundamentally prices are charged for the output of public projects because it is generally felt that it is socially desirable for those who benefit by consuming the project's output to pay the project's costs. Society also wishes that the output of its public projects be put to the highest valued uses. If prices are related to the full costs of providing the product or service then only those activities generating sufficient return to pay the full cost can command units of output of the product or service. This helps to insure that project outputs are not wasted with higher valued activities found wanting while lower valued activities receive ample supplies of the output.

Appropriate prices will also insure that, based on the output price the quantity demanded by consumers is consistent with their marginal valuations of the product or service in the uses to which it is put. The result is that the project will be of approximately the correct scale thus reducing the potentially heavy cost of idle capacity.

As we shall see in a following section, the demand patterns for many publicly provided goods or services vary markedly according to time of day, or season of the year, e.g., municipal water supplies, transit services, irrigation water and power generation. These goods and services all experience peaking of demand. In order that individuals seek the socially least cost solution to their situation, prices should reflect the cost differences involved in providing the good or service during times of peak and off-peak demand.

While prices which direct allocation of resources to their highest and best use insure that society maximizes its consumption opportunities, it must be recognized that there may be other (and sometimes conflicting) objectives which society wishes to reflect in its investment and pricing decisions. This particular issue will be taken up in greater detail in the following chapter. In the context of this pricing discussion it is sufficient to note that pricing decisions have equity as well as efficiency ramifications in that they determine the relative distribution of benefits between consumers of the project output and the public at large. An extension of this argument and a frequent objection to full cost pricing is that the poor will be disadvantaged relative to the rich since higher prices will fall more heavily on them. This of course is true no matter what prices are charged and the typical response is to suggest that if income distribution or re-distribution is a concern there are more efficient means of accomplishing this objective, e.g., subsidization of 'merit wants'.[1]

5.5.4. Conclusions and Recommendations

Investment decisions and pricing decisions must be based upon the same objectives. While the relative priority of the economic efficiency objective as measured against other objectives is ultimately a political decision, efficiency pricing has strong appeal. In view of the conventional wisdom which has it that resource development projects in the public sector are not the optimal means of redistributing income and in view of the limited empirical evidence which suggests that public projects have been only mildly redistributive, we favor efficiency pricing of the output of public projects. With efficiency pricing society's resources are more optimally allocated (ignoring 'second best' considerations) with the result that a greater surplus should be available to the government for explicit redistribution, if desired. A pricing scheme designed with the above conclusion in mind has the following elements.[1]

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[1] Merit wants may be defined as goods or services which improve the general welfare and which could be (and frequently are) provided by the private market; e.g., education, health, housing. The essence of the 'merit want' idea is that they can be publicly provided in amounts greater than would be justified by reference to private market incentives.

The first step is to establish several cost distinctions necessary for construction of efficiency prices.

i. The capital costs of expansion of output with existing capacity should be separated from the capital outlays required to develop new sources of supply.

ii. Costs of new source development.

iii. Operating, maintenance, and repair costs for the current system and for the new system if advances in technology are incorporated.

iv. Administrative and other overhead costs.

The distinction drawn in i and ii above is clear for water resource and similar resource development options. For further processing and manufacturing facilities the distinction applies, mutatis mutandis - new supply sources would be new plant capacity whereas expansion of supply with existing supply sources is equivalent to installing a new machine in an existing plant facility.

The 3-part pricing structure based on these cost distinctions is as follows.

i. A plant investment charge based on i above. The plant investment fees would be based on the costs of reasonably-sized additions to the system. The charge should be graduated according to the degree of peaking of demand (if any). In the case of an extension of service to a new area, the developer would pay the charge which would then be built into the price of land in the area.

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[1] Howe, pp. 98-100. Howe suggests this as a scheme for pricing urban water supplies but the principles apply to all types of projects with peaking demand characteristics.

ii. An increasing block rate structure based on quantity consumed which is designed to cover the marginal costs of new source development plus operating, maintenance and replacement costs.

iii. A fixed charge added to each customer's bill to cover administration costs.

GUIDELINE:

The guideline on pricing structures is simply a strong recommendation to consider pricing both in the design and operation of capital facilities. Emphasis upon efficiency in construction of public projects and in pricing of the output is of primary importance, all things considered. An outline of a 3-part pricing scheme which would make some progress toward achieving efficiency has been put forward. It can be adapted to many of the types of projects which are now under consideration and others which will be under consideration in the future.

CHAPTER 6

PROJECT EVALUATION IN THE CONTEXT OF MULTIPLE OBJECTIVES

6.1 Introduction

Historically, most project evaluations purported to be concerned primarily or solely with economic efficiency. However, upon closer examination it becomes clear that these project evaluations were concerned with only a subset of the issues involved in resource allocation based upon economic efficiency rules. There are two areas of departure of traditional benefit-cost analyses purportedly based on economic efficiency from what might be termed conceptually pure economic efficiency analysis, for want of better terminology.

i. The existence of imperfect markets

ii. Neglect of the assumptions from which economic efficiency rules are derived.

The first area of departure can be dealt with most briefly.[1] The problem involved here is the 'general theory of second best' in technical jargon. This simply means that the marginal conditions for maximum welfare (price equal to marginal social costs in all markets, etc.) are not met in one, some, or all markets. Typically, this departure from the conditions defining a welfare maximum for society has been ascribed largely to a departure from the perfect competition model. That is, firms or other institutions gained market power and were able to exhibit behavior other than profit or utility maximizing behavior. The result is a less than socially optimal allocation of resources. To be fair, economists have recognized this source of departure explicitly since the publication of the Lipsey/Lancaster article in 1957.[2] Recognition of the problem does not of course constitute a solution to the problem. There is some on-going work on the measurement of the welfare cost of monopoly[3], but there has been little work on how benefit-cost analysis might be altered in the empirical context of imperfect market structures.

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[1] See additional discussion on this topic in Chapter 5, Section 5.2.4.2

[2] Lancaster, K. and R. Lipsey, "The General Theory of Second Best", Review of Economic Studies, 1957.

[3] Harberger, A.C., "Monopoly and Resource Allocation", American Economic Review, May, 1954, pp. 77-87; and Harberger, A.C. "The Measurement of Waste", American Economic Review 54 (May, 1964) pp. 58-76.

The theoretical benefit-cost literature usually deals with this issue by describing the problem. The benefit-cost manuals and actual benefit-cost studies either ignore the problem or make reference to the problem and then continue as though there were no difficulty.[1]

The second and possibly more serious point of departure is neglect of the assumptions of the model employed to derive the efficiency rules. Some of the assumptions relevant to the current discussion are:

i. The distribution of income in society is taken as given.

ii. The consumption of goods and services by one individual reduces the total amount available for consumption by others.

iii. There are no spillover effects in production or consumption.

iv. No interpersonal comparisons of 'utility' can be made.

v. The demand curves for all goods are negatively sloped, i.e., people do not buy a good because it is more expensive and appeals to snobbery.

The failure by practitioners to be explicit about these assumptions and the failure to fully inform decision-makers and other professionals as to the limitations of analyses based on these assumptions, combined with benefit-cost analysis being held out to be the public decision-making tool, has curried an unfavorable reputation both for the tool itself and for economists who recommend its use. This reputation is not entirely unjustified in many actual cases. To make some progress toward the redress of this situation, it is proposed to deal directly with the above assumptions in a multiple objective planning framework.

Before moving on to a discussion of the methods of incorporating multiple objectives into a decision framework based on benefit-cost analysis, it is desirable to emphasize that, conceptually, the definition of economic efficiency could be broadened if it were feasible to measure all the external effects of production and consumption, if it were possible to make interpersonal utility comparisons, etc. Thus, the fundamental problem with a single but all-inclusive objective is not a problem of concept but rather one of measurement.

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[1] This document is an example of the latter procedure.

6.2 Types of Benefits and Costs

The types of benefits and costs which will be encountered in any project evaluation may be conveniently classified into three categories:[1]

i. Benefits and costs for which market prices exist;

ii. Benefits and costs for which market prices do not exist but for which values can be established by imputation and market simulation;

iii. Benefits and costs for which no market prices exist and for which no meaningful valuation could be established by imputation or simulation.

With the caveats noted in the previous section, it is roughly correct to state that what is normally construed to be economic efficiency covers the benefit and cost categories i. and ii. Recent heightened awareness of, and concern for, environmental quality, population growth, quality of life, etc., have rendered the historical emphasis upon economic efficiency somewhat narrow minded. Thus, a modified public decision-making tool must be developed to explicitly incorporate the broader issues of concern to society which were previously left to take care of themselves.

Question then arises as to precisely what are the additional objectives which society is attempting to attain. It is quite likely that the objectives are diffuse, not well articulated, possibly conflicting and not well understood. In this atmosphere it may be presumptious to attempt to identify the objectives specifically. However, it is reasonable to state broad categories within which most specific objectives would fall. The Water Resources Council in the United States has already covered this ground and has identified the following broad categories of objectives:[2]

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[1] Howe uses four categories by breaking our category i. into non-price supported commodities and price supported commodities. Generally, we regard this distinction as unwarranted in view of the degree of imperfect competition in all sectors of the economy.

[2] Water Resources Council

i. To promote economic development;

ii. To enhance the quality of the environment;

iii. To enhance social well-being;

iv. To enhance regional economic development.

If public policy is to embrace all these objectives simultaneously, we can proceed to a discussion of the means by which the contributions to the attainment of these objectives made by various projects can be evaluated.

6.3 Multiple Objectives and Project Design and Selection

There are fundamentally two procedures for incorporating multiple objectives into a project evaluation.[1] A third procedure is derived by combining elements of the two basic methods. One procedure involves designing the project to achieve maximum provincial economic efficiency subject to certain physical quantitative constraints on the level of distributional (regional development and social well-being) and environmental impacts of the project. The other method is to design and evaluate several alternative projects with a wide range of different degrees of attainment of each of the four objective areas. Still another method - a variation on the second procedure - is to design the project so as to achieve maximum economic efficiency and then evaluate alterations to the project which achieve other objectives. In this procedure, the costs of the design changes (reduction in TV(NB) are viewed as the opportunity cost of the degree of attainment of some non-efficiency objective. Viewed in this respect, the political decision-makers can determine in a subjective fashion whether the degree of attainment of that particular objective is justified by the added cost of the alteration. A more detailed discussion of each of the procedures follows.

6.3.1 Maximizing Economic Efficiency Subject to Constraints

In applying this procedure, the analyst begins with the assumption that there are project outputs or impacts which cannot be evaluated in monetary terms. Some of the impacts are quantifiable in physical terms, while others may well not be quantifiable at all. This presents the first problem in applying this procedure. Minimum acceptable levels of 'goods' and maximum acceptable levels of 'bads' must be specified before the project design can proceed. Superficially, this appears to be a technical problem, e.g., specification of minimum water flows, maximum levels of contaminants in air or water, but fundamentally it is also, and perhaps largely a political and administrative problem.[1] This point will be taken up in more detail shortly. Assuming for the moment that levels of 'goods' and 'bads' generated by a project may be specified and ignoring the problem of how this would be accomplished administratively, we may proceed to complete the description of this method. With the design constraints specified, the project engineer then designs a project which meets the constraints but promotes economic efficiency to the fullest possible extent.

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[1] Howe, p. 30

This type of design procedure will require close cooperation between the design engineers and the economic analysts who will be evaluating the project. This is one of the desirable features of multiple objective planning for it sensitizes each of the various technical experts to the problems and requirements of others.

Howe develops the following hypothetical example of this procedure.[2] "The development of a power site is being considered. The power would be used by a city or power grid considerably removed from the dam site and reservoir, but it is also determined that any recreational and flood control benefits would accrue to the residents of the immediate area of the site. To provide compensation to persons whose lives would be disrupted by the construction and existence of the project, the legislature or other relevant political decision-making body determines that x dollars of recreational and flood control benefits (or perhaps an amount equal to y% of power benefits) should accrue to such parties. Furthermore, the same decision-making body specifies that, for esthetic reasons, the maximum allowable drawdown should be z feet and that all timber and trash should be removed from the reservoir site to a contour k feet below mean pool level. These requirements then would constitute quantitative constraints under which the project designer would be obligated to work. He would then presumably proceed to locate the dam, determine its height, the size of the spillways, the length of the penstocks, and so on to maximize economic efficiency from the appropriate accounting stance."

For some types of physical impacts, existing legislation may have already established the minimum or maximum acceptable levels of certain impacts. This is particularly likely in the area of water and air pollution. For cases in which legislation is in existence, the quantitative constraints specified should be those dictated by the legislation.

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[1] In a jurisdiction with a relatively complete complement of regulatory legislation, this method might work well since, presumably, the legislation would set the standards.

[2] Howe, p. 31.

Constraints covering project impacts which are not the subject of legislation must be determined through a technical-administrative process with the knowledge of, and final approval of, the political decision-makers. Approval by political decision-makers is a very important step in the process because establishment of 'acceptable' levels is more than a technical matter as asserted earlier. Technically acceptable impact levels and socially or politically acceptable levels might well diverge. Additionally, there may be serious knowledge gaps in the technical information available which make establishment of levels on technical grounds very difficult. A relevant contemporary example is the controversy over the degree of safety associated with generation of electric power through thermonuclear processes. A political decision-maker might rightly ask himself, quite apart from technical considerations, is public concern for the safety of such devices so acute that an outright ban is warranted or should selective constraints be applied?

The final step in the application of this procedure is to gain some knowledge of how the efficiency results would be affected if the constraints were relaxed in some measure or perhaps totally. This is again an exercise in sensitivity analysis. The method is to relax each constraint one at a time and monitor the effect of the relaxation of the constraint on efficiency net benefits TV(NB).

6.3.2 Creating Alternative Designs with Differing Weights on the Several Objectives

This method begins with the presumption that there is little or no legislative direction to assist in establishing acceptable levels of 'goods' and 'bads' generated by the project. Essentially, the idea is that the project engineer designs a variety of alternatives, each of which, based on his experience, is intended to emphasize one of the four objectives. This method will be rather hit and miss inasmuch as each designer will have his own ideas as to what constitutes a project which emphasizes environmental quality or social well-being, for example. With a variety of projects designed and evaluated, the political decision-makers are then presented with a variety of alternatives from which to choose. This is in contrast to the more common situation in which a build or no-build decision faces the political decision-makers.

6.3.3 Multiple Objective Planning Through Application of Opportunity Cost Concepts

The procedure to be described below actually represents an amalgam of the two methods described above. It is different in that it renders the sacrifice of efficiency in order to meet other objectives explicit to the analyst and policy-maker. In other words, the reduction of efficiency benefits via design changes to meet non-efficiency objectives is viewed as a minimum value which the non-efficiency benefits must exceed in order for the design change to be acceptable. The method may be described in greater detail by the following example.[1]

Having chosen a public investment program which represents the most efficient use of a given resource base, it is necessary to account opportunity costs associated with provision and protection of non-monetary values associated with non-efficiency objectives.

Assume the following hypothetical scenario. On strictly efficiency grounds, the Fish Development Corporation, a Crown corporation set up by the Government of Ruritania, has decided to regulate the flow of the Rurita River. The project is multi-purpose, providing for fish production, navigation, flood control, recreation and relief of regional unemployment. The project is assumed to consist of the following components, namely dam, reservoir, fish enhancement facilities, recreation facilities and navigation works. Account has also to be taken of adverse impacts on non-efficiency objectives (i.e. objectives which cannot be stated in purely monetary terms). Adverse impacts are foreseen on environmental and social well-being values (e.g. distribution of enhancement windfalls to high income fishermen, inundated portions of the upstream valley contain a unique and valuable ecology, some homesites are inundated, etc.) Further, account should be taken of possible enhancement of intrinsic benefits through modification of the project. Non-efficiency objectives can therefore appropriately be introduced. The costs of meeting such objectives in terms of income foregone can then be weighed against the intrinsic benefits provided.

The case of the Rurita River outlined above can be usefully developed to illustrate the procedures involved. The first step of the analysis is to illustrate the income maximization alternative which emerges from the process described in Chapers 1 through 5 above. Step two consists in illustrating an alternative constrained by non-efficiency objectives. The project purposes and components are assumed to be as outlined above. It is decided, in discussion with the decision-makers, that the following classes of intrinsic benefits should be subsumed under non-efficiency objectives:

(a) Environmental Benefits

(b) Social Well-being Benefits, and

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[1] Reid, D.J. "Evaluating the Costs of Opportunities Foregone", a paper prepared for the Working Group on Benefit-Cost Analysis, B.C. Hydro and Power Authority, January, 1975, mimeo. Changes in the example have been made to maintain consistency with guidelines recommended elsewhere in this document.

(c) Regional Benefits

Tables 1 - 3 display the unconstrained income maximization alternative with terminal value of gross benefits, terminal value of total costs and terminal value of net benefits shown in succeeding tables. Benefits are shown to have a terminal value of $800 m. Costs amount to $500 m. The terminal value of net benefits is, thus, $300 m.

Tables 4 - 6 display a development alternative which allows for protection and enhancement of intrinsic values associated with the environmental, social and regional well-being accounts. Tables 1 and 2 assume that the project is modified to preserve and enhance such values.

Table 4 shows the changes in efficiency benefits which result from:

i. Environmental and Social Well-being Preservation

   a) The dam is lowered to flood out fewer people and to protect ecologically valuable upstream areas.

   b) The reservoir is regulated to prevent ugly mudflat formation and to enhance recreational opportunities.

   c) The reservoir is stocked with sport fish.

ii. Social Well-being Enhancement

   a) Flood protection program is to be aimed at low income farmers on marginal lands in keeping with income distribution objectives.

   b) A program is established to give a larger share of the catch to low productivity fishermen than would be justified by efficiency criteria.

iii. Regional Well-being Enhancement

   a) A programme is established to hire and train more local unemployed labor than would be justified by efficiency criteria.

As a result, flood control, navigation and fish benefits are somewhat reduced while recreation and employment benefits are increased. In all, total income benefits are reduced from $800.0 m. to $750.0 m in terminal value of net benefit terms.

Table 5 shows the impact of non-efficiency objectives on costs. Basic investment costs, the cost of achieving efficient design without regard to adverse impacts on non-efficiency objectives, now undergo some change. A lower dam requires lower construction costs and lower property acquisition costs. The flood control, navigation and fish enhancement facilities also cost less under newly-specified labor intensive methods. Only the efficient amount of recreation facilities to be provided at the reservoir site now costs more to provide. Operation and maintenance costs are assumed to remain unchanged. However, additional costs are specified in consultation with decision-makers, to protect and enhance intrinsic values. A whole range of costs of this type have been included under the heading 'mitigation costs'. They range from landscaping the enhancement facilities to additional, market-determined compensation payments to evicted local residents. As a result, total income costs are raised from $500.0 m. to $595.0 m.

The terminal value of net benefits are reduced from $300.0 m. to $155.0 m. as shown in Table 6. The opportunity cost of achieving non-efficiency objectives with respect to protection and enhancement of intrinsic values is thus $145.0 m. Total income reduction can be shown to be divided among the non-efficiency objectives as follows:[1]

	$m.
Environment	- 104.0
Social Well-being	- 71.0
Regional Development	+ 30.0
TOTAL INCOME REDUCTION	- 145.0

Whether the intrinsic benefits provided in the form of environmental, social well-being and regional development values are worth more or less than the income foregone is left to the judgment of the decision-maker. If the cost is decided to be too high, then the expectations with respect to non-efficiency objectives can be scaled down. A satisfactory solution might only be achieved after several iterations.

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[1] For example, the environmental objective reduces income by $45.0 m. and raises mitigation costs by $79.0 m. Construction costs, however, are reduced by $26.0 m. in total and this is divided between the environmental and social well-being objectives in proportion to benefits provided. Thus, cost of meeting the environmental objective is $45.0 m. $+ \$74.0\text{ m.} - \frac{45.0}{80.0}(\$26.0\text{ m.}) = \$104.0\text{ m.}$

TABLE 1

UNCONSTRAINED INCOME MAXIMIZATION
TABLE OF BENEFITS
50 YEAR ANALYSIS, HYPOTHETICAL DATA

	OUTPUT CATEGORY	EVALUATION BASIS	DISCOUNT RATE(2) %	TERMINAL VALUE $m.
1.	Fish Production	Cost of best alternative protein food supply (e.g. price of fish products on world market)		
	(a) Example Project		10	200.0
	(b) Downstream Benefits to Existing Projects A, B and C		10	50.0
2.	Flood Control and Navigation	Reduction in loss of life and property. Change in net income arising from increasing economic activity on floodplain and along the navigable waterway	10	250.0
3.	Recreation	Imputed net benefits based on willingness to pay etc. (1)	10	250.0
4.	Unemployment and Underemployment Benefits	Increase in income of beneficiaries	10	50.0
	TERMINAL VALUE OF GROSS BENEFITS ($m.)			800.0

(1) Estimated base year recreation value, imputed from willingness-to-pay, is $5.50 per visitor-day. Number of visitor-days assumed to grow at 3.5% for 20 years at which point capacity constraint becomes effective. Numbers then decline at 2% per year over the following 30 years.

TABLE 2

UNCONSTRAINED INCOME MAXIMIZATION
TABLE OF COSTS
50 YEAR ANALYSIS, HYPOTHETICAL DATA

	ITEM	COSTS PAID BY	DISCOUNT RATE %	TERMINAL VALUE INVEST-MENT	$m. OPERAT-IONS	TOTAL
1.	Dam and reservoir	Agency	10	90.0	10.0	100.0
2.	General property acquisition	"	10	100.0	-	100.0
3.	Fish enhancement facilities	"	10	60.0	40.0	100.0
4.	Navigation facilities	Federal	10	15.0	5.0	20.0
5.	Flood control facilities and equipment	"	10	70.0	10.0	80.0
6.	Recreation facilities	Agency	10	10.0	40.0	50.0
7.	Roads, sewage, water supply	Agency/Local	10	30.0	20.0	50.0
	TERMINAL VALUE OF TOTAL COSTS ($m.)			375.0	125.0	500.0

TABLE 3

UNCONSTRAINED INCOME MAXIMIZATION TOTAL BENEFITS, COSTS, TERMINAL VALUE OF NET BENEFITS AND BENEFIT-COST RATIO - 50 YEAR ANALYSIS HYPOTHETICAL DATA

ITEM	PRESENT VALUE ($m.)
Terminal Value of Total Benefits	800.0
Terminal Value of Total Costs	500.0
Terminal Value of Net Benefits	300.0
Terminal Value of Total Investment Costs	375.0
Terminal Value of Benefit-Cost Ratio	1.6

TABLE 4

ALTERNATIVE CONSTRAINED DEVELOPMENT
TABLE OF BENEFITS (1)
50 YEAR ANALYSIS, HYPOTHETICAL DATA

OUTPUT CATEGORY	TERMINAL VALUE OF NET BENEFIT CHANGES COMPARED TO UNCONSTRAINED ALTERNATIVE IN CONSIDERATION OF:(2)		TOTAL TERMINAL VALUE OF BENEFIT (14)
		$m.	$m.
1. Fish Production			
(a) Example project	Environment (3)	- 30.0	160.0
	Social Well-being		
	(4)	- 5.0	
	(5)	- 5.0	
(b) Downstream benefits to existing projects	Environment (6)	- 15.0	30.0
	Social Well-being		
	(7)	- 2.5	
	(8)	- 2.5	
2. Flood Control and Navigation	Environment (9)	- 30.0	200.0
	Social Well-being		
	(10)	- 15.0	
	(11)	- 5.0	
3. Recreation	Environment (12)	+ 30.0	280.0
4. Regional Unemployment and Underemployment Benefits	Regional Development (13)	+ 30.0	80.0
BENEFIT REDUCTIONS FOR ENVIRONMENTAL ENHANCEMENT		- 45.0	
BENEFIT REDUCTIONS FOR SOCIAL WELL-BEING IMPROVEMENTS		- 35.0	
BENEFIT INCREASES IMPUTED TO USE OF UNEMPLOYED RESOURCES		+ 30.0	
TOTAL TERMINAL VALUE OF BENEFITS ($m.)			750.0

Notes on Table 4

(1) Evaluation basis and discount rates as per guidelines above.

(2) These two columns identify the origins and terminal value dollar amounts for terminal value of net benefit changes relative to the unconstrained income maximization plan.

(3) Reduction in height of dam to reduce flooded area of aesthetic and valuable ecological portions of upstream valley. Reduction in drawdown.

(4) Reduction in reservoir size to minimize the number of families flooded out of the upstream valley.

(5) Decrease in net income as a result of a decision to protect local, low productivity fishermen consistent with an equitable redistribution objective.

(6) As (3)

(7) As (4)

(8) As (5)

(9) As (3)

(10) As (4) and use of more unemployed and underemployed labor force than would otherwise be necessary on the basis of economic efficiency. This sum represents foregone benefits in terms of delay and low efficiency in order to achieve a better income distribution.

(11) Decrease in net income as a result of decision to protect marginal farmland and low value properties consistent with an equitable income-redistribution objective.

(12) Increase in recreational value as a result of the improvement of the reservoir.

(13) Representing secondary benefits accruing to the region.

(14) Total value of benefits does not include the value of intrinsic benefits arising from the enhancement of environmental, social and regional well-being. Therefore, total income benefits may underestimate the real value of benefits.

TABLE 5

ALTERNATIVE UNCONSTRAINED DEVELOPMENT
TABLE OF COSTS (1)
50 YEAR ANALYSIS, HYPOTHETICAL DATA

	ITEM	COSTS PAID BY	TERMINAL VALUE OF BASIC INVESTMENT COSTS (2)	TERMINAL VALUE OF MITIGATION COSTS IN CONSIDERATION OF: (3)		TERMINAL VALUE OF OPERATION COSTS	TOTAL TERMINAL VALUE OF COSTS
			$m.		$m.	$m.	$m.
1.	Dam and reservoir	Agency	80.0	Environment (4)	20.0	10.0	110.0
2.	General property acquisition	"	90.0	Environment (5)	10.0		
				Social Well-being (6)	10.0		
				(7)	5.0		
				(8)	5.0		120.0
3.	Fish enhancement facilities	"	55.0	Environment (9)	5.0	40.0	105.0
				Social Well-being (10)	5.0		
4.	Navigation facilities	Federal	10.0	Environment (11)	15.0	5.0	30.0
5.	Flood control facilities and equipment	"	68.0	Social Well-being (12)	15.0	10.0	100.0
				Environment (13)	7.0		
6.	Recreation facilities	Agency	16.0	Environment (14)	7.0	40.0	70.0
				Social Well-being (15)	7.0		
7.	Roads, sewers, etc.	Agency/ Local	30.0	Environment (16)	10.0	20.0	60.0
	TERMINAL VALUE OF BASIC COSTS		349.0			125.0	
	ADDITIONAL COSTS FOR ENVIRONMENTAL ENHANCEMENT				74.0		
	ADDITIONAL COSTS FOR SOCIAL WELL-BEING				47.0		
	TOTAL INCOME COSTS						595.0

Notes on Table 5

(1) Discount rates as per guidelines above.

(2) Basic investment costs represent the minimum costs incurred to provide an efficient design for each project purpose without accounting for adverse effects on non-efficiency objectives.

(3) Costs associated with mitigation actions to enhance or reduce adverse effects on non-efficiency objectives.

(4) More thorough reservoir clearing; reservoir bank stabilization measures; fish stocking.

(5) Acquisition of land to protect flora and fauna of reservoir area.

(6) Compensation payments to evicted local residents.

(7) Subsidy payments to local community to acquire cultural and sports facilities.

(8) Land acquisition for waterfront parks.

(9) Additional costs for landscaping fish enhancement facilities to minimize aesthetic damages in a wilderness area.

(10) Subsidy to low productivity fishermen to improve distribution of income from enhancement.

(11) Additional costs to improve public access along navigation channel.

(12) Subsidy to marginal farmers to increase agricultural efficiency and improve income distribution.

(13) Dyking to protect valuable natural environments from flooding.

(14) Additional costs for enhancing educational facilities at the fish enhancement site.

(15) Additional campsites in local parks.

(16) Longer project main access route to avoid critical wildlife habitat.

TABLE 6

ALTERNATIVE CONSTRAINED DEVELOPMENT
TERMINAL VALUE OF TOTAL BENEFITS AND COSTS
TERMINAL VALUE OF NET BENEFITS
AND BENEFIT-COST RATIO

ITEM	TERMINAL VALUE ($m.)
Total Benefits	750.0
Total Costs	595.0
Net Benefits	155.0
Total Investment Costs	470.0
Benefit-Cost Ratio	1.26

GUIDELINE:

The recommended method of dealing with non-efficiency objectives within the context of benefit-cost analysis is to apply opportunity cost concepts to the efficiency analysis as shown in the above example.

6.4 Compensation, Mitigation and Multiple Objective Planning

6.4.1 Introduction

A great deal of currency within provincial government circles is presently being accorded the concepts of compensation and mitigation in the context of major project evaluation. There appears to be some uncertainty whether a distinction exists between these two concepts and, if so, the conditions under which one or the other action is appropriate to a given set of circumstances. The present discussion represents an attempt to define the concepts and thereby to clarify the distinction between them. Our aim is to establish any principles which may be applied in determining whether compensation should be paid and/or if mitigation should be undertaken and, if so, to what degree.

6.4.2 Background

The discussion of compensation in the economics literature has a long and somewhat involved history. Without completely retracing the historical development, we shall review important points relevant to this discussion. It should be noted in advance that the terms compensation, income redistribution, and equity are used synonymously by economists and all refer to changes in the present distribution of wealth among individuals caused by either public or private actions.

It is safe to say that modern welfare economics has attempted to concern itself with achieving the most efficient allocation of resources This entails achieving the highest output value subject to certain constraints and given a distribution of income (and wealth).[1] Technically, this involves finding that output level for all final goods and services at which the prices and marginal production costs are equalized and at which these two are in turn brought to equality with marginal satisfactions derived by consumers in consumption. On the basis of these ground rules, once this position has been attained it is impossible to reallocate resources and make one individual better off without simultaneously making another worse off. This is the Paretian position of maximum welfare. However, this maximum welfare position is dependent upon individuals' income and wealth levels.[1] Generally, as people's income change, their demand curves for final goods and services change and probably their supply curves of services rendered to the productive process will also change. Thus, different income and wealth positions imply different relative prices at the Paretian position as well as different 'optimal' output mixes. Welfare economics begs the question of optimal distribution of income preferring instead to leave this highly sensitive but important issue to politicians, policy makers, society or somebody else.

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[1] Much of the discussion of Chapter 1 is closely related to this present discussion.

That this efficiency-equity dichotomy is appropriate in a technical sense is the subject of several propositions of welfare economics called compensation criteria. Several such criteria have been advanced in recent (since 1935) welfare economics literature. The specific aim of the persons who advanced the criteria was to establish an area of policy analysis within which economists could conduct technical studies to compare one set of economic circumstances against another and rank them in respect of the objective(s) of public policy without beginning from ethical premises or value judgments. Economists felt that if economic theory was to be useful for attacking practical economic and social problems, some way of avoiding value judgments in analysis would have to be found.

The first attempt to establish such a criterion was made by N. Kaldor[2] who stated a criterion now known as the Kaldor-Hicks criterion. The Kaldor-Hicks criterion is comprised of two parts: (i) If, as a result of some policy somebody is made better off and no one is made worse off, the policy is a good one: (ii) Kaldor went further and argued that if a policy benefitted somebody and harmed somebody else, economists could still argue that the policy was beneficial overall if the benefitted parties could compensate the parties harmed. Whether the compensation was actually paid was a political or ethical judgment. For Kaldor the important point was that the possibility of compensation established the potential superiority of the policy.

Shortly after this proposition was advanced, it was proven that it was capable of self contradiction.[3] The gainers, in a move from situation A to situation B might indeed be capable of fully compensating the losers and still be better off in B than in A. However, it is possible that the losers might, after the movement to B, be in a position to bribe the gainers and return to the A position.

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[1] In other words, the additional utility (marginal utility) of income is dependent upon the individual's income and wealth levels.

[2] N. Kaldor, "Welfare Comparisons of Economics and Interpersonal Comparisons of Utility", Economic Journal, 1939.

[3] T. Scitovsky, "A Note on Welfare Propositions in Economics", Review of Economic Studies, Volume IX (1) (1941-2), pp. 77-88.

To eliminate this potential internal contradiction, Scitovsky suggested that another part be added to the Kaldor-Hicks criterion. This addition came to be known as the Scitovsky reversal criterion and essentially states that as between a move from A to B, assuming compensation is not paid, a move back from B to A should not meet the Kaldor-Hicks criterion. Even this is insufficient to make the Kaldor-Hicks criterion consistent since Nath[1] proves that contradictions are still possible.

The modified Kaldor-Hicks criterion came under criticism from Samuelson on the grounds that if a comparison between two positions is to be completely neutral on the subject of distribution, the move to the new position should be superior to the old position as judged by all possible distributions in both the positions.[2] This Samuelson comparison has come to be known as the Samuelson criterion, although it was not advanced as such. Samuelson was merely suggesting a refinement of the Kaldor-Hicks criterion which he felt had been overlooked. Of course, Samuelson's refinement establishes only the potential superiority of one position over another for all possible distributions in each. Actual superiority depends upon establishment of the social welfare function for the community.[3]

The final criterion of a priori welfare economics was advanced by I.M.D. Little at about the same time as Samuelson's refinement appeared. Little sought a criterion by which it would be possible to compare actual rather than just potential superiority of a position. Little thought that ethical judgments regarding the favorable or unfavorable character of changes in distribution ought to be included as part of the criterion. Therefore, he proposed combining a judgment about distributions of income in any two positions with the Kaldor-Hicks and Scitovsky reversal criterion.

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[1] Nath, S.A., A Reappraisal of Welfare Economics, Routledge and Kegan Paul (London, 1969), p. 100.

[2] Samuelson, P.A. "Evaluation of Real National Income", Oxford Economic Papers, 1950.

[3] Nath, p. 104.

Unfortunately, the Little criterion breaks down immediately since it is possible for the Kaldor-Hicks and Scitovsky reversal criterion to give contradictory results.[1]

There are several points to notice about the 'New Welfare Economics' described above. If we write a social welfare function in symbolic form as is commonly done in expositions of welfare economics, we can see some of these points more clearly

$$(6.1) \qquad W = W(U^1, U^2, \ldots, U^s)$$

In equation (6.1) above, W is social economic welfare and $U^1, \ldots, U^s$ are the utilities of each of the s individuals in society.

The first thing to notice about the social welfare function is that it is defined on the utilities of individuals in society. The origin of the social welfare concept is due to Bergson[2] who stated a relation between social (general) welfare and all the possibly relevant variables, such as work and consumption, in addition to other economic variables. Bergson stated that for relatively small changes in the economic variables, other elements of welfare will not be significantly affected. From this statement the social (economic) welfare concept was born. If social (economic) welfare depended on income and wealth of individuals and individual utility also depended upon income and wealth then, by simple substitution, welfare must depend upon individual utility; hence, the form of the social (economic) welfare function and the separation of economic welfare from general welfare[3] which is the second point to notice about the social welfare function.[4]

Now, it is normally argued that individual tastes differ and every time relative prices change, money incomes must also change; otherwise, to think of distribution in terms of money incomes involves rigidifying the existing distribution of relative technological scarcities of goods.

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[1] For an exposition of additional criticisms of the Little criterion see Nath, pp. 105-116.

[2] Bergson,

[3] Many of the points in this exposition are made in Nath, A Reappraisal of Welfare Economics.

[4] It is easy to think of examples which indicate that economic welfare and general welfare cannot be separated.

However, this problem can be dealt with in the following way. The first step is to realize that a welfare function defined on individual per capita money incomes, wealth and leisure is rather unrealistic. Therefore, redefine the welfare function to employ the same independent variables but aggregate from individuals to groups of individuals with common characteristics such as money incomes, age, marital status, size of family, state of employment, etc. Then simply assert that the political decision-maker's ethical belief is that individuals in these groupings be regarded as if they had similar tastes unless there is some special evidence to the contrary about a certain sub-group as defined by the above characteristics. Now, if relative prices change, individuals in each group respond to the changes in the same manner.

On the basis of this 'eclectic' welfare economics, we may put forward a simpler and more realistic welfare function

$$W = W(E, a, b, R, G) \tag{6.2}$$

The exact relationship between the dependent and independent variables of this welfare function is undefined. It simply states that general welfare (w) is dependent upon employment levels (E), the equality of the distribution of income and wealth (a, b), the rate of growth of provincial product (R), and a variable which describes 'non-economic' factors affecting welfare (G). In this formulation, the independent variables are the targets of public policy which are attained through such instruments of public policy as taxes, subsidies, direct public investment and pricing policy of public enterprises.

Armed with this background on the 'New Welfare Economics' and our eclectic formulation of a general social welfare function which is defined on both economic and 'non-economic' variables, we are now prepared to discuss and formulate guidelines on compensation and mitigation in the sphere of direct public investment.

6.4.3 Compensation and Mitigation Defined

Merriam Webster's Pocket Dictionary defines compensate as:
(1) to be equivalent to in value or effect; counterbalance;
(2) pay, remunerate. The definition of mitigate given is: (1) to make less harsh or hostile; (2) to make less severe or painful. Roget's Thesaurus does not show either of the words as a synonym of the other. Definitionally, it appears that the terms compensation and mitigation are distinct.

Conceptually, the dividing line between compensation and mitigation is not always clear. Nevertheless, let us make an operational distinction for purposes of the following discussion. Mitigation shall refer to a change in structural design, construction timing or location of a physical facility undertaken for the express purpose of reducing or eliminating any deleterious effects of the construction or operation and maintenance of such facilities on the natural or human environment. Mitigation would therefore include installation of baffles at the end of an airport runway as well as construction of fish ladders at a dam site. Mitigation would also include outlays to improve the post project productivity of one or more natural resources adversely affected by the project construction.

Compensation shall refer to a transfer payment, either in kind or in money, of a sum whose amount is determined to be the change in the income of a group of individuals identified by various socio-economic factors as discussed above. The basic motivation behind compensation is the 'gainers compensate the losers' ethic which recognizes that income distribution impacts of projects may be adverse and seeks to redress these adverse impacts.[1]

6.4.4 Policy Targets, Mitigation and Compensation

We now have three ingredients for establishing procedures with which to handle mitigation and compensation. We have

i. a formulation of a 'welfare function' defined explicitly on the policy targets British Columbia deems of importance. That is, provincial income (economic efficiency), distribution of income, and quality of the natural and social environment.

ii. a methodology developed by example in some detail in section 6.3.3 which shows how a project may be evaluated on the basis of the effects it has on these policy targets.

iii. an operational definition of the terms mitigation and compensation.

We can now relate mitigation and compensation activities to the various policy targets defined in the welfare function.

GUIDELINE:

Mitigation refers to changes in the design, construction timing and/or location undertaken for the purpose of meeting the standards for

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[1] Of course, income distributional impacts may just as well be beneficial. Presumably the beneficial impacts would remain uncompensated.

natural and social environmental quality espoused by the Province. Compensation refers to transfer payments between the government and groups of individuals for the purpose of meeting the income distributional objectives of the Province.

The economic flows which a project such as that in the example above sets up can be classified into monetary and non-monetary. A further division of each of these into allocative or efficiency flows and distributional flows is possible. Early benefit-cost analyses (circa 1950's - 1960's) were concerned largely with monetary allocative flows. The project evaluation criteria herein evidence an interest in and concern for analysis of all four classes of economic flows.

Except as noted above in the section on adjustments for unemployment and imperfect markets, we may assume that all monetary allocative flows represent full payment for the resources so utilized. This is equivalent to assuming that these resources are earning their opportunity costs. Generally, we will probably not be too wide of the mark with this assumption.

We cannot assume that monetary distributive effects are always 'correct' (i.e., in accord with society's desires). Take a hypothetical example to illustrate a case in which these flows may not be 'correct'. Assume that personal income taxes are increased in order to fund an irrigation program for farmers in a particular region. Taxpayers generally now have lower after-tax income. Assume further that irrigation benefits farmers with large land holdings more than those with small holdings (lands formerly cultivated in an extensive fashion may now be cultivated more intensively). The final assumption is that these larger holdings are farms which are typically limited companies. We may now begin to view the monetary distributive flows set up by this project. Farmer's incomes are greater at the expense of lower incomes for taxpayers generally (farmers are taxpayers too and pay higher taxes but receive benefit so their net position is better than before the project). Large farmers benefit at the expense of small farmers and taxpayers generally. Large incorporated farms benefit at the expense of small and large unincorporated farms and taxpayers generally.[1] These are all monetary distributive flows which may or may not be desirable. If undesirable, then corrective action is warranted. This corrective action may take a variety of forms. That is, any of the policy instruments - a change in public investment policy, pricing, taxes or subsidies - available to government may be employed to redress the undesirable effects. Whether taxes and transfers are made is a political decision.

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[1] In conducting such an analysis, the analyst would need to exercise caution so as to avoid double counting.

Some allocative effects which are non-monetary at the time and/or place of their occurrence are rendered monetary by the legal system. These are the cases which are covered by nuisance law.[1] It is the non-monetary allocative effects not redressed by the legal system which are important for this discussion. These are the effects which are included in our definition of the term mitigation. The means of handling mitigation of non-monetary allocative effects is the subject of section 6.4.6.

Typically, these effects are so diffuse and/or long-term that they may not be recognized as allocative effects. Obvious examples are air and water pollution. Also typical of this type of economic flow is that it frequently affects resources which are publicly owned - common property resources. Thus, normally no one individual's interest is affected substantially enough to warrant his raising an issue. However, collectively, society's interest may be materially affected.

Non-monetary distributive effects will be comprised largely of the effects on the social well-being of one region versus another. Project impacts of this type should be redressed by direct income and wealth taxes and transfers if the project impacts are considered to be sufficiently undesirable to a particular region.

6.4.5 Compensation

GUIDELINE:

Analysis of the regional income redistributive effects (monetary distributive effects and non-monetary distributive effects) should be conducted. The analysis should highlight the income changes caused by the project which take place among various socio-economic groupings of individuals as defined on page 117. This analysis will form the basis for any desired transfer schemes to be decided at the political level.

6.4.6 Principles for Determining the Extent of Mitigation

It is suggested that the economic principles which apply to project evaluation in general also apply to mitigation in particular. Presumably, outlays to effect mitigation measures will have a 'pay-off' in the form of (at least) an equivalently large reduction of the opportunity costs of particular resources adversely affected by the proposed project.

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[1] See Ronald Coase, "The Problem of Social Cost", Journal of Law and Economics, October 1960; reprinted in Readings in Micro-economics, edited by William Breit and Harold M. Hockman, Holt Rinehart and Winston, New York, 1968.

The costs of a mitigation activity will normally be readily assessable. However, the benefits of the mitigation may or may not be easily discernable. Where benefits and costs are both monetarily determinable by methods described above, the desirability of the mitigation can readily be judged. For cases in which the benefits are not determinable in monetary terms, physical dimensions may be used to describe the benefits of mitigation and a political decision is required to establish the social merit of the mitigation measure.

Establishment of mitigation alternatives will normally require a wide range of technical expertise. Therefore, it is anticipated that the private or public agency involved in evaluating a proposed project according to these Guidelines will coordinate with a variety of government departments and agencies, particularly at the provincial level but also at the federal level as well. The appropriate clearing-house for this coordination is the Environment and Land Use Secretariat. Through this mechanism, a variety of mitigation alternatives should be suggested, researched and evaluated according to the Guidelines established here. These mitigation alternatives would become part of the final benefit-cost evaluation.

If, due to physical constraints, a project is deemed to possess insufficient opportunities to mitigate some or all of the deleterious environmental and social effects so as to meet the standards established in these areas, other off-site means of mitigation may be considered. Such off-site alternatives should, however, be in the same general region as that occupied by the project. Thus, for example, consider the case of a hydro dam which partially or completely displaces valuable wildlife habitat which supports an active and growing recreational resource (hunting, viewing, hiking, etc.). In addition, assume that the dam is sufficiently attractive as judged by the other objectives that it is decided to proceed with the project but that decision-makers on the project determine that the loss of habitat constitutes sufficient degradation of environmental quality that some other form of mitigation is desirable (no change in design that is feasible and safe will avoid the flooding of the habitat). The decision-makers suggest that the agency responsible for development of the project provide funds for intensified management of other similar habitat in the same general area but outside of the region of direct influence of the project. The amount of funds allocated for this intensive management program does not necessarily have to equal the loss of the value of recreational services provided by the original habitat. However, the original value loss should set an upper bound on the expenditures for intensification of management.

The only proviso attached to decisions on mitigation measures is that the benefits of mitigation, whether objectively or subjectively determined, should at least equal the costs of undertaking the measure.

GUIDELINE:

It seems clear from this discussion that mitigation measures, as defined above, can and should be placed within the overall project evaluation and should be subject to the principles and procedures involved in carrying out a social benefit-cost analysis. Off-site mitigation may be considered as warranted by circumstances.

CHAPTER 7

MISCELLANEOUS TOPICS IN BENEFIT-COST ANALYSIS

7.2 Contents of the Chapter

Some issues in benefit-cost analysis do not fit neatly into the topical categories of chapters one through six. This chapter will therefore be used as a catch-all for topics of importance which do not fit into the previous six chapters. It is anticipated that this chapter will grow over time as particular issues arise in the application of the Guidelines to project evaluation in B.C.

7.2 Taxes, Royalties and License Fees in Benefit-Cost Analysis

Frequently, governments tend to view increased tax revenue as benefits of a proposed development project. This probably results from a private industry view of the operations of governments. While taxes represent an important source of revenue for most governments, financial flows in the form of increased tax revenues do not represent real flows and in particular should not be accounted among the benefits of a project. As described in some detail above, opportunity costs and opportunity returns are the fundamental concepts which determine whether particular items are benefits or costs, properly construed. If we apply the opportunity cost standard to tax payments, it is immediately clear that such payments are not opportunity costs from society's viewpoint. Tax payments do not represent a claim on society's real resources. Therefore, tax payments do not affect the social profitability of a proposed investment.

While tax payments should not enter directly into the benefit-cost analysis, this is not to suggest that they are not important. Just as industrial corporations will analyze the effect of cash flows on their financial position over time, government should inform itself of its own cash flow position resulting from the proposed project. Thus, tax revenues are extremely important components of financial analyses which are in turn components of the overall analysis of the project.

Large scale economic development projects typically require infrastructural investments. These infrastructural investments will normally entail some degree of government involvement either directly or through Crown corporations. Such is the case, for example, in the coal developments currently proposed for the eastern sector of British Columbia. The tax and financing issue will thus appear to the analyst to loom large. Fortunately, however, the actual sharing of the financial burden between government and private industry does not affect the efficiency benefit-cost analysis. As indicated above, the analyst should account all benefits and costs as measured by the opportunity cost yardstick to whomsoever they may accrue.

Thus, benefit-cost analysis of the proposed project(s) should proceed at an early stage in the project planning process.

Clearly, the sharing of the financial burden of the investment between government and industry could have a marked effect on the distribution of the net gains or losses from the project. Thus, again, government will want to begin its financial and distributive analyses as early in the planning process as is feasible. The main point has been to emphasize that, since the tax and royalty payments are not regarded as opportunity costs and since the sharing of the financial burden does not affect the occurrence of or size of benefits and costs, lack of information on these topics need not delay the commencement of the benefit-cost analysis of the project.

GLOSSARY OF TERMS

allocative effects: syn., efficiency effects; changes in uses of productive resources which change an economy's productive capability. Distinguished from distributive effects which do not affect an economy's productive capability but do affect the distribution of final output.

benefit-cost analysis: A framework, based on economic principles and concepts, for organizing information important for evaluating and comparing the consequences of a series of economic events. Applied welfare economics.

compensating variation: In the event that a project were to proceed, that amount an individual would willingly accept or pay and be in the same welfare position as before the project.

compensation: see distributive. A transfer payment from one group of individuals to another normally achieved through a tax and transfer system, as distinct from the usual legal interpretation of compensation. For example, unemployment insurance, welfare payments, etc.

compensation principle: Generalization of the Pareto criterion. Holds that a policy should be implemented only if the gainers can potentially compensate the losers as a result of the policy or decision. Actual compensation may or may not take place.

competitive price: That price for a good or service which equals the marginal cost of supplying the good or service, i.e., as occurs in a price competitive market. See price competition.

constant dollar: syn., real dollar. Units for expressing values or price for which inflationary effects *have* been removed.

consumer's surplus: That part of the total value to a consumer of a good or service for which the consumer does not pay because the market is well developed, impersonal, and contains many buyers and sellers. Difference between market price and willingness to pay as represented by a demand curve.

current dollar: syn., nominal dollar. Units for expressing values or prices for which inflationary effects have *not* been removed.

distributive: syn., equity, distribution. The effect of a public project on the relative distribution of income within the referent group.

economic efficiency: syn., efficiency, optimal resource allocation. A state pertaining to the production and distribution of a good or service in which the price of the good or service equals its marginal cost. See Pareto criterion.

economic growth: Expansion of the economy's productive capacity measured on a per capita basis. Normally measured by GNP per capita or some similar measure.

economic rent: A surplus which a productive factor receives in payment beyond that which would be necessary to call forth its services. Consequently, that part of payment to a productive factor which could be appropriated without affecting the supply of the productive factor's service forthcoming. *Ricardian* rent refers to economic rent received by relatively superior land due to its long-term fixity of supply. *Quasi*-rent refers to the economic rent received by a resource whose supply is fixed in the short run but can be augmented in the long run.

economies of scale: A productive circumstance in which a doubling of inputs results in a more than doubling of outputs.

efficiency goal: see economic efficiency. The goal is price equals marginal cost.

efficiency pricing rule: see economic efficiency.

engineering economics: A narrowly focused economics concerned with achieving the optimum structure for, e.g., a plant or other physical asset.

equity objective: An objective which pertains to the relative distribution of incomes among groups in an economy.

equivalent variation: The amount an individual would have to pay or receive to leave him in the same welfare position if the economic event in question did not take place.

exchange value: The price at which a good or service changes hands. Distinguished from value in use. The two values may diverge.

existence value: The value which individuals place upon the knowledge of existence of an aesthetic or amenity resource even though they know with certainty they will never use it.

externality: An efficiency effect which occurs as the result of a production or consumption process but which is unpriced.

inflation rate: The rate at which a general price level increases. Usually expressed as a quarterly or annual rate based on the price level in some arbitrarily chosen year.

intermediate goods and services: Goods and services which have received some level of processing but which are not final consumption goods.

demand curve: A schedule of prices at which purchasers are willing to buy associated quantities of the good or service in question.

marketed benefits: Goods or services produced as the result of a project and which are bought and sold in an organized market.

merit wants: Goods or services which can be and are provided by the private market but have an element of "publicness" about them in the sense they can be publicly provided economically in larger quantity than would be justified by the private market.

mitigation: A change in the design, scale, timing of construction or location of a project for the express purpose of reducing the negative externalities of the project.

net present value: A widely used investment criterion which results from discounting to the present, the difference between benefits and costs of a project in each period during which the project has benefits or costs.

nominal rate of interest: The stated interest rate which includes both real and inflationary elements, if any.

non-efficiency objectives: Objectives for public action which cannot be construed as aimed at directly improving resource allocation within the economy.

non-exclusive goods: syn., collective consumption goods, public goods. Goods for which any individual or economic agent's consumption does not reduce the total amount available for consumption by other economic agents.

non-marketed values: see non-priced user benefits.

non-priced user benefits: Service value which a project bestows upon certain individuals who are not required to pay for the service due to its not being sold in an organized market.

normalizing procedure: A procedure for placing the benefits and costs of projects on a common basis so that consistent ranking of the projects will result from application of any investment criterion.

opportunity cost: The net value of output sacrificed by using productive resources in one way as opposed to some other.

optimum scale: The scale of a project beyond which further changes lead to no further efficiencies, i.e., the scale at which the marginal net benefit from a scale change equals zero.

option value: The value which an uncertain but potential future user of a service would be willing to pay or receive for the option to buy the supply available.

Pareto criterion: A state in which no reallocation of resources can improve economic welfare.

present value: The value today of a payment or stream of payments to be made or received in the future.

preservation value: see existence value.

price competition: A form of competitive behavior in which suppliers in a particular market compete for customers on the basis of the price charged.

rate of return: A measure of the success of an investment. Requires a basis, i.e., rate of return on capital is the net return (gross return - cost) of a capital investment divided by the value of the capital. Also requires a time dimension for calculating net returns - usually a year.

real interest rate: The nominal interest rate adjusted for any inflationary components.

referent group: syn., referent area. That group of individuals for which the receipt of benefits or incurrence of cost will be included in the benefit-cost analysis. The referent group normally consists of all individuals within the boundaries of the political jurisdiction carrying out the analysis.

relative prices: The price ratio between two or more goods or services.

risk: A situation in which the outcome of an event has a probability of less than 1.0 but for which the probability of outcome can be estimated. Risk can be insured against; e.g., loss of life, fire, etc.

sacrifice cost: see opportunity cost.

sensitivity analysis: A type of analysis which seeks to identify whether project rankings or decisions are sensitive to changes in important parameters or variables whose values are uncertain.

shadow pricing: The adjustment of accounting prices to account for various causes of distortion from freely competitive, market determined prices.

social accounting system: two possible meanings. A general reference to the process of conducting a social benefit-cost analysis is the meaning employed in the guidelines. Another meaning is as a reference to the compilation of macro-economic statistics such as is carried out by Statistics Canada.

social benefit-cost analysis: see benefit-cost analysis. The adjective social is sometimes appended to distinguish the type of analysis from its more narrowly focused private sector counterpart.

social infrastructure: transportation and communication systems, public health maintenance systems, educational systems. Generally, public goods. See public goods.

social investment criterion: The criterion used to make decisions on and rank public investment opportunities.

social opportunity cost of capital: (S.O.C.) The opportunity cost of using productive resources in public project. Measured by the profitability with which those resources could be employed in the private sector. Used as a basis for calculating the social rate of discount.

social rate of discount: That rate of discount, measured either by the social opportunity cost or social time preference, to be used in calculating the value of the social investment criterion for projects.

social time preference: (S.T.P.) The rate at which society prefers present to future consumption. Some economists argue that this should be the basis for establishing the social discount rate.

social welfare function: An abstraction used to determine a theoretical welfare maximum. The social welfare function transforms the utilities of individuals into an aggregate index of social welfare.

socially profitable: A relative term which refers to projects that are admissible on the basis of the social investment criterion.

subsidies: A payment (normally from government) for the purpose of inducing some form of behavior which would not be justified on the basis of market economics alone.

supply curve: A schedule of prices at which suppliers of a good or service are willing to supply given quantities of the good or service.

terminal value: The future value of a payment or series of payments compounded forward at some rate.

transfer payments: see compensation. A lateral payment between two or more groups in society normally channelled through the government.

uncertainty: An event for which the probability of a specific outcome cannot be estimated. Uncertainty cannot be insured against; e.g., 'acts of God' - famine, earthquake, etc.

welfare economics: A branch of economics which seeks to understand how the economic well-being of a society may be measured and by what economic policies economic well-being may be improved.

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APPENDIX A

EMPIRICAL STUDIES
OF
REAL RATES OF RETURN IN CANADA

The first study to measure the social opportunity cost of capital for Canada was conducted by G.L. Reuber and R.J. Wonnacott in 1961.[1] Reuber and Wonnacott present a 'borrowing model' approach to estimation of the social opportunity cost. Real rates of interest as defined below were estimated on the alternative assumption that the project (development of the Columbia River) would be financed through the Federal Government on the one hand and the British Columbia Government on the other. Analyses were performed assuming both Canadian and United Stated sources of funds.

Real rates of interest were defined as, "....a percentage indicating (a) the return, expressed in real terms, yielded by the nation's marginal investment, and (b) the time preference of the marginal saver, this rate being the degree to which he prefers present over future real purchasing power."[2] This definition is partially consistent with our definition of the social opportunity cost of resources as stated earlier in this paper although, as we shall see, the measurement is somewhat different owing to the borrowing model methodology.

Measurement of real rates of interest for Canada and B.C. begins with the financial rate of interest on long-term Government of Canada bonds. These bonds are regarded as riskless and therefore establish a basis on which to rank relatively riskier debt instruments. Real rates of interest will equal the financial rates of interest providing the following conditions hold as stated by the authors: "(1) expectations remain constant, most notably the expectation that prices remain stable; (2) there are no distortions in interest rates because of short term pressures exerted by governmental monetary and fiscal policies; (3) there is a pure and perfect capital market, implying that there is no capital rationing."[3] The authors, recognizing that in general, the above conditions do not hold, devote the remainder of the study to a quantification of the effect of government fiscal and monetary policy and imperfect capital markets on the real rate of interest faced by Canada and B.C. in borrowing both domestically and in United States financial markets.

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[1] Reuber, G.L. and R.J. Wonnacott. The Cost of Capital in Canada - With Special Reference to Public Development of the Columbia River, Resources for the Future, Washington, D.C., 1961.

[2] Ibid., p. 5. In view of the conditions required to establish the equivalence of (a) and (b), Reuber and Wonnacott's definition of real rates of interest appears to be somewhat inconsistent.

[3] Ibid., p. 6.

Quantifying the above four factors as indicated in the "Differential" column of the table below, Reuber and Wonnacott arrive at the real rates for each sector as shown. For convenience, we shall reproduce the author's Table 7 (p. 51) as Table 1 below.[1]

TABLE 1: REAL RATES OF RETURN
IN VARIOUS MARKET SECTORS
- CANADIAN SOURCE FINANCING
(Percent)

Borrowing Sector	Federal "real" rate	+	Differential	=	"Real" rate for sector
Federal direct financing	4.75		.00		4.75
Federal guaranteed financing	4.75		.05		4.80
Provincial direct financing	4.75		.55		5.30
Provincial guaranteed financing	4.75		.60		5.35
Municipal financing	4.75		1.00		5.75
B.C. direct financing	4.75		.35		5.10
B.C. guaranteed financing[2]	4.75		.40		5.15
Private utility (comparable to B.C. Electric)	4.75		.80		5.55

Small business and mortgage sectors are added to the analysis by observing the range of rates to small business and concluding that the average financial rate is 7%. Making the necessary adjustments as in Table 1, the real rate for small business is 6.25 percent. In a similar fashion, by observing both N.H.A. and conventional mortgage rates, a real rate for mortgages of 5 3/4 percent is obtained.

The weighted average opportunity cost of Federal and British Columbia Direct borrowing is then calculated. Table 8 of the study showing this calculation is reproduced below as Table 2.

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[1] Ibid., p. 51.

[2] It is interesting to note that a guarantee of the B.C. Government carries an interest rate approximately ½ of 1 percent lower than that for the private utility without the guarantee.

TABLE 2: OPPORTUNITY COST OF FEDERAL AND BRITISH COLUMBIA DOMESTIC BORROWING

Sector Sacrificing Funds	Weight (percent)	Relevant Real Rate	
		Federal Borrowing (percent)	B.C. Borrowing (percent)
1. Consumption and other projects of the borrower	10	4.75	5.10
2. Mortgages (housing and small business	35	5.75	5.75
3. Provinces	17	5.30	5.30
Municipalities	18	5.75	5.75
4. Business -			
Mainly inventories and private utilities	10	5.55	5.55
Small business	10	6.25	6.25
Weighted average		5.60	5.64

The weighted average social opportunity cost of capital in 1961 is thus found to be of the order of 5.6 percent. This is a real rate of return with inflationary expectations removed. To employ this rate in a discounting calculation, costs and returns must both be shown in constant dollars.

A similar method of analysis is employed to estimate the weighted average opportunity cost of capital from United States sources and considering only Canadian welfare. Adjustments are made for foreign exchange risk, political considerations, institutional conventions and legal restraints. For a detailed discussion of this portion of the study the reader is referred to Chapter 5.[1]

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[1] Ibid., p. 54 and passim

A more recent attempt at estimating the social opportunity cost of capital in Canada employs a different method and utilizes significantly better data than the previous study reported.[1] The method employed by Jenkins is to use financial statements (balance sheets and profit and loss statements) for 2 and 3 digit Standard Industrial classification levels as base data. Accounting conventions, income and excise taxation cause divergence between social and private accounting as described above. Accordingly, Jenkins makes certain adjustments to the balance sheets and financial statements of the 2 and 3 digit industries in order to transform the statements into consistency with the definitions of economics

Briefly described, the following adjustments are made.

(a) The value of fixed assets is adjusted to reflect replacement cost. The adjustment is performed by assuming that the rates of current dollar replacement cost of net stock of buildings and equipment for each industry at each time period to the gross stock of buildings and equipment in original cost dollars for each industry at each time period is the same. This rate is then calculated for each industry from unpublished data supplied by Statistics Canada. Applying the ratio to the current book value of buildings and equipment for each industry yields the replacement cost of assets adjusted for inflation and relative prices as well as adjusting the gross value of economic depreciation.

(b) The rate of return to the operations of each industry is the relevant parameter being estimated. Yet many non-financial companies hold financial assets. Accordingly, the net value of assets was reduced by the value of financial assets held by non-financial concerns. Working capital is defined as cash, accounts receivable less accounts payable, inventories and prepaid expenses.

(c) Depreciation expense allowable for income tax purposes is adjusted to reflect actual economic depreciation. Economic capital consumption allowance data for the total industry was obtained from unpublished Statistics Canada data. That portion allocable to each industry was calculated proportionately, based on net capital stock for each industry in each time period.

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[1] Jenkins, Glenn P., "The Measurement of Rates of Return and Taxation from Private Capital in Canada", in Benefit Cost and Policy Analysis, A.C. Harberger, et al, editors (Chicago: Aldine Company) 1972.

(d) Debt charges, taxes and charitable donations are added back to income since these items are part of the value of the product produced even though they are regarded as expenses of doing business by the firm in question.

(e) Income from financial assets held by non-financial corporations is subtracted from income as defined for economic purposes. (Note item (b) above.)

(f) The Federal Government's manufacturers wholesale tax, as well as sales taxes collected by the Provincial Governments, constitute part of the value of products. Under certain conditions (fixed proportions production functions) these taxes can be translated as taxes on output or labor and capital value added. When the tax rates are different for different sectors or when the depreciation rates of the capital stock are not all the same, different industries will experience different social rates of return.

(g) An adjustment to revenues is made for accrued capital gains and losses resulting from changes in relative prices of capital assets of business firms. However, since capital gains and losses should be included in rates of return only when they are anticipated, for the application purposes of the study these 'extraordinary items' are not employed.

Calculation of social rates of return for certain sectors such as mining, mineral fuels, agriculture and residential housing required additional modification for consistency with the above. In the mining sector, exploration and development expenditures are considerable and, for tax purposes, are expensed against current income. However, such expenditures are in the nature of capital expenditures since they represent depletable assets. Due to difficulty in segregating provincial tax revenues obtained from mineral rights sales and royalties for each industry, the capital stock and income data for refineries and mineral fuel industries was aggregated.

Calculating rates of return in agriculture presented several problems. The agricultural sector is heavily subsidized by federal and provincial support programs. In order to evaluate the social rate of return in the industry, an estimate of the financial benefit to this sector provided by the complex of subsidy programs was made. Much of the financial rate of return to agricultural enterprises is comprised of wages to the owner-operator and his family. In order to correct for this element, the author used an upper and lower bound estimate of imputed income. The upper bound estimate was made by assuming that all non-wage farm labor earned income equivalent to paid farm workers. Since part-time family labor constitutes approximately 30 percent of the agriculture labor force, the resulting estimate of labor income to the owner-operator and his family is high. The lower bound estimate is constructed by assuming that owner-operators earn an income equivalent to paid farm workers but that family labor earns a zero wage.

Owner-occupied housing contains an element of income-in-kind since it provides a flow of housing services. Two adjustments were made in the housing sector. Net income from owner-occupied housing was calculated from unpublished Statistics Canada data. A data series on the owner-occupied housing stock was calculated by multiplying the current value of the total residential housing stock by the ratio of gross imputed rent on owner-occupied housing to the total rent (paid plus imputed). Finally, an adjustment was made for the implicit subsidy provided by the exemption from income taxes on capital gains on the equity portion of the housing stock. This adjustment was calculated by assuming that the marginal tax rate of all taxpayers owning homes is 25% and applying this rate to the equity portion of the capital gain (owner's equity assumed to be 50% of total capital value in the owner-occupied housing sector).

The non-corporate industrial sector was handled by estimating the non-corporate capital stock from Statistics Canada data for the total industrial sector and subtracting the corporate portion of the total industrial sector. The private rate of return in this sector is assumed[1] to equal that in the corporate sector. Accordingly, the social rate of return in the non-corporate sector would equal the social rate in other corporate sectors minus the rate of corporate income tax paid on all assets.

The results of the calculations made by Jenkins are presented in his Table I which is reproduced below as Table 3. The information presented in this table is highly significant and very useful. It may of course be

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[1] Based on some evidence that this is so. See L.R. Cristensen, "Entrepeneurial Income: How Does It Measure Up." American Economic Review, Vol. LXI, No. 4 (September, 1971)

TABLE 3. RATES OF RETURN AND TAXATION FROM CAPITAL IN CANADA BY SECTOR (AVERAGE, 1965-1969)

Industry	1 [d]Private Rate of Return Excluding Capital Gains and Losses	2 [e]Private Rate of Return Including Capital Gains and Losses	3 [f]Property Tax as a Percentage of Net Fixed Assets and Working Capital	4 [g]Income Tax as a Percentage of Net Fixed Assets and Working Capital	5 [h]Sales Taxes as a Percentage of Net Fixed Assets and Working Capital	6 [i]Cross Rate of Return Excluding Capital Gains and Losses and Sales Taxes	7 [j]Social Rate of Return Excluding Capital Gains and Losses Including Sales Tax
1. Foods and Beverages	7.99	7.21	.79	5.10	15.78	13.88	29.66
A. Food Industries	6.67	5.87	.77	3.49	.41	10.94	11.34
B. Soft Drinks	10.82	9.91	.91	5.82	5.06	17.25	22.30
C. Breweries and Wineries	11.57	10.88	.68	10.28	74.16	22.52	96.68
2. Tobacco Products	6.95	6.66	.37	6.41	119.27	13.73	133.00
3. Rubber Products	5.15	4.48	.41	3.31	2.54	8.86	11.41
4. Leather Products	5.19	4.91	1.06	2.69	3.54	8.94	12.48
5. Textile Mills	4.81	3.65	.51	2.31	1.40	7.62	9.01
6. Knitting Mills	6.21	4.87	.84	3.09	5.62	10.14	15.76
7. Clothing Industry	6.57	6.06	.88	2.99	4.47	10.44	14.92
8. Wood Industry	6.98	5.79	.51	2.90	.14	10.39	10.53
9. Furniture	6.62	5.95	1.26	2.75	4.61	10.63	15.23
10. Pulp and Paper and Allied Industries	4.65	3.63	.56	2.22	.21	7.44	7.65
A. Pulp and Paper Mills	4.56	3.17	.52	1.98	.11	7.07	7.17
B. Paper Boxes and Convertors	6.73	5.69	1.07	5.26	1.29	13.06	14.34
11. Printing and Publishing	9.49	8.76	.73	5.42	1.02	15.64	16.66
A. Commercial Printing	8.28	7.57	.78	3.39	1.86	12.45	14.31
B. Publishing	2.35	1.32	.11	1.54	.21	4.00	4.21
12. Primary Metals	6.02	4.92	.23	2.29	.27	8.53	8.79}
13. Metal Fabricating	6.51	6.10	.67	3.77	.66	10.96	11.62}
14. Machinery Industries	9.10	8.77	.45	4.61	1.58	14.17	15.75
15. Transportation Equipment	7.73	7.25	.59	5.39	9.34	13.71	23.04
A. Aircraft and Parts	4.22	3.89	.40	.66	.92	5.29	6.20
B. Motor Vehicles	11.45	10.59	.70	8.38	16.54	20.54	37.08
C. Miscellaneous Transportation	4.05	3.63	.65	3.80	1.14	8.50	9.65
16. Electrical Industries	6.37	5.82	.46	3.07	4.30	9.90	14.20
A. Electrical Industrial Equipment	5.54	4.98	.73	2.77	1.27	9.04	10.32
B. Other Electrical Products	7.03	6.43	.31	3.33	6.13	10.68	16.81
17. Non-Metallic Mineral Products	6.09	5.06	.46	2.39	.50	8.95	9.44
18. Petroleum and Coal Refineries	5.84	4.91	1.33	1.35	4.71	8.51	13.22
19. Chemical Industries	6.33	5.39	.45	4.26	.91	11.03	11.94
20. Miscellaneous Manufacturing	6.47	5.98	.72	5.10	3.32	12.29	15.61
21. Total Manufacturing	6.45	5.53	.61	3.32	4.77	10.38	15.14
22. Total Construction	6.54	6.24	.68	2.61		9.82	9.82
A. Building Contractors	4.92	4.79	.81	2.12		7.84	7.84
B. Highway and Bridge Construction	6.33	5.98	.41	2.76		9.50	9.50
23. Total Transportation	2.62	.59	.82	1.06		4.50	4.50
A. Air Transport	3.49	1.81	.36	.35		4.20	4.20
B. Water Transport	1.78	-.28	.27	.58		2.64	2.64
C. Railways	1.03	-1.00	.67	.90		2.60	2.60
D. Truck Transport	9.08	7.67	3.24	2.71		15.03	15.03
E. Pipelines	6.56	4.28	.64	1.92		9.12	9.12

Industry	1 dPrivate Rate of Return Excluding Capital Gains and Losses	2 ePrivate Rate of Return Including Capital Gains and Losses	3 fProperty Tax as a Percentage of Net Fixed Assets and Working Capital	4 gIncome Tax as a Percentage of Net Fixed Assets and Working Capital	5 hSales Taxes as a Percentage of Net Fixed Assets and Working Capital	6 iGross Rate of Return Excluding Capital Gains and Losses and Sales Taxes	7 jSocial Rate of Return Excluding Capital Gains and Losses Including Sales Tax
24. Storage	4.00	4.14	1.33	1.18		6.50	6.50
A. Grain Elevators	3.27	3.41	.62	1.01		4.89	4.89
B. Storage and Warehouses	6.05	5.96	3.61	1.96		11.62	11.62
25. Communications	6.54	5.26	.84	2.53	.48	10.40	10.88
A. Radio and Television	5.71	4.56	.50	3.95		10.16	10.16
B. Telephones	7.00	5.29	.87	2.53	.53	10.41	10.94
26. Public Utilities	5.57	1.41	.91	1.78	.61	8.27	8.87
A. Electrical Power	4.97	.69	.81	2.00	.66	7.78	8.44
B. Gas Distribution	6.32	2.21	1.00	1.57	.58	8.89	9.47
27. Wholesale Trade	7.72	7.57	.76	3.61	3.65	12.09	15.73
28. Retail Trade	7.59	7.38	1.62	3.53	.44	12.73	13.17
29. Total Finance, Insurance, and Real Estate	4.22	4.21	.23	.39		4.84	4.84
A. Trust Companies	4.81	4.81	.04	.34		5.19	5.19
B. Mortgage and Loan Companies	5.16	5.17	.01	.20		5.27	5.27
C. Banking	3.30	3.29	.02	.41		3.73	3.73
D. Total Deposit Accepting Institutions	3.27	3.28	.02	.36		3.65	3.65
E. Total Investment Companies	4.89	5.26	.04	.25		5.17	5.17
a* 29. Total Finance, Insurance, and Real Estate	6.74	6.73	.90	1.52		9.16	9.16
*A. Trust Companies	6.64	6.67	.48	4.05		11.16	11.16
*B. Mortgage and Loan Companies	10.07	10.17	.17	2.17		12.41	12.41
*C. Banking	8.57	8.31	.38	9.02		17.96	17.96
*D. Total Deposit Accepting Institutions	7.51	7.55	.29	6.20		14.00	14.00
*E. Total Investment Companies	6.10	6.10	.06	.33		6.48	6.48
30. Total Services	9.88	9.83	1.46	2.24	.17	13.58	13.75
A. Services to Business and Management	17.42	17.07	1.05	7.34		25.82	25.82
B. Personal, etc., Services	9.43	9.53	1.46	1.65	.19	12.54	12.73
31. Total Non-Manufacturing	6.25	5.31	.95	2.01	.50	9.21	9.71
32. Mining	7.36	n.a.	.38	2.42		10.16	10.16
33. Mineral Fuels	4.94	n.a.	.42	.80		6.18	6.18
A. Mineral Products and Petroleum Refineries	5.34	n.a.	5.05	1.06	2.27	11.45	13.71
34. Agriculture	2.46	5.20	.89	-.63		2.83	2.83
b** 34. Agriculture	4.31	6.35	.20	-.03		4.48	4.48
35. Rental Housing	5.33	7.84	2.43	nil		7.86	7.86
36. Owner Occupied Housing	5.38	7.84	2.48	-.67		7.19	7.19
37. Trade (Non-Corporate)	7.34	7.19	1.13	nil	2.27	8.47	10.74
c 38. Total All Activities	5.82	n.a.	1.49	1.13	1.11	8.44	9.54

a. The rates of return and taxation in categories *29A through *29E for financial intermediaries are based on the value of equity in the sector and the private rates of return only include income accruing to the equity holders.

b. The rates for non-manufacturing exclude 29 but include *29 for financial intermediaries.

c. The rates of return for the total of all activities excludes categories 29 and 34 but includes *29 and **34.

d. (Table 3 ÷ Table 2) x 100 and averaged over the five years 1965-1969.

e. (/Table 3 + Table 4/ ÷ Table 2) x 100 and averaged over the five years 1965-1969.

f. (Table 5 ÷ Table 2) x 100 and averaged over the five years 1965-1969.

g. (Table 6 ÷ Table 2) x 100 and averaged over the five years 1965-1969.

h. (Table 7 ÷ Table 2) x 100 and averaged over the five years 1965-1969.

i. (/Table 3 + Table 5 + Table 6/ ÷ /Table 2/) x 100 and averaged over the five years 1965-1969.

j. (/Table 3 + Table 5 + Table 6 + Table 7/ ÷ /Table 2/) x 100 and averaged over the five years 1965-1969.

used for determining a weighted average discount rate to be employed in the evaluation of public projects in British Columbia. For governments faced with a range of private investment proposals, the final column, (7), as well as columns (3) - (5) provide valuable information for decision-making purposes.

For purposes of estimating the social opportunity cost of capital in Canada, the latter study is preferred. Our preference for this study is primarily methodological. Recalling the definition of the social opportunity cost of capital, it is seen that the rates of return estimated by Jenkins fit precisely that required by the definition. The former study presented a 'borrowing model' approach in which the social opportunity cost of capital in each sector was assumed to be the real borrowing rate faced by each sector. The Jenkins study also highlights the differential rates of investment productivity and taxation in each sector. Other reasons for preferring this study are the more recent data coverage and the much greater sectoral detail provided.

A word about terminology is in order. Jenkins refers to his rates of return as 'social' rates of return. What he means, of course is rates of return calcualted according to and reflecting economic concepts - economic rates of return. For these rates of return to be truly social rates of return would require adjustment for externalities occurring between industries as well as between industry and society generally.

APPENDIX B

EXAMPLE COMPARISON OF RANKING OF PROJECTS BY COMPOUNDING AND DISCOUNTING METHODS

Example to show consistency of ranking between TV(NB) and NPV Criteria.

Project A:	t_1	t_2	t_3	t_4	t_5
Gross Benefits	0	10	15	20	30
Total Costs	10	15	20	10	10

Project B:					
Gross Benefits	0	15	20	20	20
Total Costs	5	20	20	10	10

Discounting: (10% Discount Rate)

NPV Project A 2.2 ; Ranking B> A
NPV Project B 4.3

Compounding: (10% Compound Rate)

TV(NB) Project A 23.15 ; Ranking B> A
TV(NB) Project B 32.85

APPENDIX C

Application of the Guidelines for Benefit-Cost Analysis to An Hypothetical Example

Development of Sodium Sulphate Deposits in the Northern Sector of Metroruritania

1.0 Introduction

The participants of Amalgam Limited, a consortium of mining interests with worldwide mining operations have carried out an extensive exploration program in the northern sector of Metroruritania, a remote area characterized by extreme weather conditions. Extensive deposits of sodium sulphate have been discovered and test drilling has taken place. Core samples have proven the large extent and high quality of the deposits anticipated during the later phases of the exploration program. Some of the deposits are situated on privately owned land whereas other portions of the deposit lie on Crown land. Amalgam has managed to secure title to all the private land and is now approaching the government in search of license to the deposits on Crown land and is also seeking government approval to develop the whole project.

The Government of Metroruritania instructs its experts to prepare an evaluation of the proposal it has received from amalgam Limited. Consideration is to be given to the overall social profitability of the investment taking into consideration the effect of the project on the natural and human environment in this region as well as the redistributional aspects of the project. The experts are also asked to prepare a government flow of funds statement in order to highlight the effect of the project on the government's financial requirements. The purpose of this statement is to insure the availability of sufficient funding to take care of existing and planned projects in addition to any items to which the government might obligate itself in relation to the proposed development of the Skunk sodium sulphate deposits. Further details of the proposed project are outlined below.

2.0 Detailed Description of the Project[1]

The raw material will be mined and processed at the mine site and will then be dispatched by rail.

2.1 Characteristics of the Deposit and Method of Exploitation

A detailed technical study has been carried out jointly by Amalgam's technical staff and the firm David Smith and Company who are specialists in mining and processing of minerals. The report of Smith and Company concludes that, having regard to the satisfactory geological and chemical characteristics of the deposit, the sodium sulphate can be extracted and concentrated without difficulty. The sodium is surface mined and is to be processed at site. After processing the sodium is ready for use.

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[1] This example is adapted from a case study appearing in "Manual of Industrial Project Analysis in Developing Countries: Methodology and Case Studies". Volume 1. Development Centre, Organization for Economic Co-operation and Development. Paris, 1968.

2.2 Transport of the Sodium Sulphate

The deposit is in a remote area with no present means of transport. In view of the quantity of material involved only rail transport can be considered. A new rail line 16 miles long will have to be built in order to connect the mine and processing plant with the existing rail system carrying the sulphate to port.

2.3 Labor Supply

The isolated location of the deposit makes it necessary to provide all the facilities and amenities essential for the personnel to live there - housing, shops, a school and medical facilities. Approximately fifty percent[1] of the labor force will be recruited from a town in the region approximately 200 miles from the site. The remainder will migrate from outside the province.

2.4 The Market

A characteristic feature of the sodium sulphate market in Metroruritania is the small number of consumers. Five companies producing kraft pulp and paperboard account for almost 70 percent of local consumption. At the present time the country is consuming approximately 180,000 tons per year, all of which is transported from domestic locations outside the province. Other industries for which sodium sulphate is an important input (textile fibers, dye stuffs, detergents and tanning materials) are not important industries in the province at the present time. Supplies of inexpensive sodium sulphate could act as a stimulus to development and expansion of these industries, particularly detergents, which at present is supplied almost entirely by a neighboring country. In view of the rapidly growing market for pulp and paperboard and the solid long-term price prospects, the major paper companies in the province feel they could absorb a 30% increase in sodium sulphate consumption by the time the mine and plant become operational - approximately 2-3 years. The companies have confirmed in writing their readiness to purchase approximately 30,000 tons of sodium sulphate at the proposed price of $23.00 per ton.

While the domestic market provides a good basis, the export market is expected to provide major growth potential. A rapidly expanding glass and textile fiber industry in a neighboring country in addition to the steadily growing pulp and paper industry is expected to absorb the difference between domestic consumption and the projected output of the mine and processing plant. It is estimated that up to 60,000 tons per year can be shipped into this market in the neighboring country.

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[1] For the capital intensive version of the project. The labor intensive version will locally recruit approximately thirty percent of the labor force.

2.5 Study of Profitability

Based on information supplied by the technical study performed by David Smith and Company in addition to 'in-house' engineering and financial analysis performed by the Amalgam technical staff, a profitability study has been prepared. This study has been forwarded to the government for review and for use by government economists who have performed the government's benefit-cost analysis. Most of the estimates of private benefits and costs (revenue and expenditure) have been taken from this report.

2.6 Alternative Technologies and Sales Programs

2.6.1 Alternative Technologies

In conjunction with Amalgam's corporate planning staff, engineers have worked out two alternative technologies for mining and processing the sodium sulphate. One technology may be characterized as relying relatively more heavily upon capital inputs. This technology is preferred by Amalgam since it came out as the most profitable alternative in Amalgam's profitability study. The other technology relies relatively more heavily upon labor inputs. Government economists decide to extend the analysis of both alternatives to determine which is socially most profitable. The capital intensive alternative shall be referred to as CI and the labor intensive alternative as LI. Analysis is conducted for an output of 75,000 tons per year and 100,000 tons per year for each of the technologies.

2.5.2 Alternative Sales Programs

In consultation with Amalgam's corporate planning staff, government economists work out several alternative sales programs to characterize the possibility that the export market might not develop as rapidly as expected, or not at all. Each of these sales programs is evaluated under the capital and labor intensive project designs. We thus have alternatives $CI_{1,2,3}$ and $LI_{1,2,3}$.

Based upon extensive market survey work and estimation of the demand for sodium sulphate, these sales programs appear to characterize a reasonable range of alternatives.

3.0 Calculation of the Net Social Benefits of the Development

3.1 The Account System

Benefits and costs of the proposed development which are capable of quantification will be included in the provincial income account. Non-quantifiable effects of the project on the quality of the natural and social environment will be included in the environmental quality and social well-being accounts, respectively. It is recognized that the account system is simply a devise to organize the information in a manner which facilitates decision-making particularly when 'trade-off' analysis is performed between the various accounts. Ultimately, all effects of the project affect the provincial income account, that is, when income is defined broadly as in Chapter 1. The income distribution/regional development objective/account will be handled as an adjunct to the benefit-cost analysis.

3.2 The Range of Alternatives

While benefit-cost analysis is best applied to illuminate a broad range of alternatives we are concerned here with a relatively narrow range of options, i.e., a capital or labor intensive development of the sodium sulphate deposits. Several reasons for this situation are:

(i) it is largely a development financed by private sector sources although the success of the project is dependent upon access to the deposits lying beneath Crown land;

(ii) no other major capital projects are planned by the government at this time; i.e., there are no other structural alternatives to the project although a non-structural alternative does exist. An income tax reduction equivalent to the government's capital contribution is analyzed as an alternative to the development.

The point in (i) above implies that a further option available to the government is to disallow access to the resources.

3.3 Evaluation Methodology

The benefit measurement principles outlined in Chapter 2 may be applied to estimation of the benefits of the project. Since the product is an intermediate good, some difficulties arise in estimation of its value. For that part of the output exported, the gross sales value reflects the gross benefits. Since Amalgam conducted extensive market research and demand forecasts, we can rely on their estimates of annual overseas shipments of product and the related prices. (See Table I for forecast shipments.) Based on this research, a price of $25.00 per ton F.O.B. port will be sufficient to penetrate foreign markets.

Domestically, based on marginal cost it appears that Amalgam will enjoy a competitive advantage to both alternative domestic and foreign sources of sodium sulphate. In discussions with Amalgam's marketing staff, it appears that they intend to set prices so as to take full advantage of this situation. Amalgam will thus earn a measure of economic rent on each ton shipped into domestic markets. This economic rent will be counted among the gross benefits of the project. The domestic price of $23.00 per ton leaves a margin of $2.50 per ton between price and Amalgam's marginal cost (cost includes a return which would be sufficient to induce Amalgam to make the investment). We know that Amalgam's cost per unit is constant over most of the output range. Thus, the price-cost spread at the margin multiplied by the quantity shipped, closely approximates the economic rent.

According to Amalgam's analysts, the relative price prospects for sodium sulphate are stable. That is, it is not anticipated that sodium sulphate could enjoy any degree of relative price escalation over the operating life of the mine. An independent verification of this came from Metroruritania's Natural Resources Department - Mining Branch. Experts in that department estimate that only a 20% relative price increase per ton is required to induce slightly higher cost technology sources of supply.

Since Amalgam intends to price in this way, there is no possibility that producers using sodium sulphate will enjoy any cost advantage. Thus, there will be no change in consumer's surplus at the final consumption level. The main market effect of the mine will be to reduce the quantity of imported sodium sulphate. In these circumstances, the sales value of the intermediate good approximates the increased value of final goods consumed. Gross benefit calculations are in 1976 dollars.

3.4 The Provincial Income Account

3.4.1 Calculation of Gross Benefits

The calculation of gross benefits is derived from the information in Table I in which shipments are broken down by domestic and export category together with the price information in Section 3.3 above. Table II contains the calculation of the annual gross benefits of the project. The calculation of the terminal value of gross benefits in year 2000 is found in Table X.

In spite of the fact that the government of Metroruritania employs a multiple-objective framework in its project evaluations, for this particular project there are no other purpose benefits generated by this project which may be included in the provincial income account. While it is true that the area surrounding the Skunk deposits will receive added recreational activity from the employees of the mine and processing facility, the areas of their present residence will receive reduced activity of a corresponding amount and value therefore leaving no net increase in value of recreational activity from the provincial viewpoint.

3.4.2 Calculation of Social Costs of the Project

3.4.2.1 Evaluation Methodology

The social costs of the project will be accounted in terms of the opportunity costs of the resources consumed by and committed to the project. This includes the social opportunity cost of labor and capital applied directly to the project in addition to the incremental changes in the value of other resources whose status is affected by the developments.

3.4.2.2 Capital Cost Estimates

The background information for calculation of capital cost estimates was obtained from the Smith and Company technical report in addition to information from Amalgam's engineering staff. In several subsequent meetings between government economists and Amalgam's staff, additional information was obtained and points of clarification were discussed. Tables IIIA and IIIB contain the capital costs for the alternatives CI and LI, respectively. Tables IVA and IVB contain the anticipated timetable of construction and development activity at the site for the CI and LI alternatives, respectively. Note that the expenditure to increase plant capacity takes place in 1990. Also, note that the total capital costs are broken down by domestic and foreign purchases. This breakdown will be helpful in later analyses.

Amalgam anticipates building housing and services to accommodate approximately 400 families for the capital intensive plan and approximately 480 for the labor intensive plan. Basically, Amalgam will be putting up the bridge financing for planning, development and construction of the units. Amalgam also expects to carry the mortgages on the houses and will be offering these mortgages at less-than-market rates an an inducement to draw workers to the mine site. Over time the mortgage program will return a positive net revenue but the return will not be what Amalgam could earn by investing equivalent funds in its best alternative opportunity. In these circumstances, the construction of the townsite represents a real cost to society and therefore is included among the opportunity costs of the projects. The mortgage and other financial arrangements between Amalgam and its prospective workers determine the distribution of that real cost between Amalgam and the workers and therefore is of interest for the distribution analysis but not for the benefit-cost analysis.

The calculation of the terminal value of capital costs of the project in year 2000 is found in Tables XI and XII.

3.4.2.3 Operating Costs

Operating costs for alternatives CI and LI are found in Tables V and VI, respectively. Most of the cost estimates were derived from information contained in the David Smith and Company technical report as well as from information obtained from Amalgam's technical and financial staff. Explanatory notes are contained on the sheet following Table VI.

The calculation of the terminal value of operating costs is found in Tables XI and XII.

3.4.3 The Opportunity Costs of Land and Appurtenant Natural Resources

3.4.3.1 Fish and Wildlife Habitat Reduction

The development of the mine, plant and townsite as well as the new transportation links will affect the habitat of resident fish and wildlife populations in an adverse way. Fisheries and wildlife biologists have made estimates of annual losses due to direct effects (moose, elk, deer killed by vehicles and trains) as well as of the chronic, long-term effects of habitat changes on the ability of the schools and herds to maintain given population sizes. However, for purposes of economic evaluation it is man's present or potential intended future use of these resources and the value that is derived therefrom that we wish to measure.

At the present time, the fish and wildlife resources in the area of the Skunk deposits which would be affected by the proposed development receive relatively light usage by the residents of Metroruritania. This is due to the relative isolation of the resources and the existence of similar quality resources closer to the major areas of population concentration. However, it is anticipated that future use will grow - more rapidly with the proposed development - but nevertheless will grow without the development due largely to the apparent secular decline in both quality and quantity of substitute resources.

Unfortunately there is little or no data on the extent of present use of these resources. Valuation will have to proceed on the basis of a number of assumptions and inferences as well as results of studies which have been conducted elsewhere.

Without the project it is determined that the area will continue to receive relatively light usage for the next five years. This is based on a review of the data and information on the present use of other recreational resources throughout the province. Basically it is clear that existing relatively heavily used resources can continue to experience growth in use for the next several years without any significant reduction in quality. However, after this time use levels will be such that further increases will result in quality deterioration which will in turn induce recreationists (largely hunters and sport fishermen) to seek other recreational resources. Thus, beginning in 1982, growth in use of the Skunk area fish and wildlife resources is estimated to be 1.5% per year. This growth is on top of a current base usage of approximately 600 hunter-days annually and 300 angler days as estimated by regional fish and wildlife biologists. Information from other areas of the province where data and information is more complete and where specific studies have been conducted from time-to-time indicates that the willingness-to-pay (based upon individual's observed expenditure behavior) for a hunter-day lies in the range $15 - 20 while that for an angling-day is in the range $6-$9. Given the abundant wildlife based recreation opportunities in Metroruritania in relation to demand, it is not possible to foresee a major increase in relative value of a hunter-or-angler-day for some years to come, at least beyond the time horizon of this project. The determination of recreation value is found in Table VII.

With the project a number of divergent events will occur. With the development of the area and the attendant population influx, the number of hunter- and angler-days consumed in the Skunk area will increase. This increased use is due to the proximity of the resource to the people who come to work in the mine and not to the relatively declining quality of similar resources elsewhere as was the case without the project. In fact, it is estimated that the quality of the Skunk area hunting and fishing experience will decline due to crowding and to a resultant reduction in the success rate. Additionally, some of the increased hunting and fishing activity in the Skunk area is activity which would have occurred in other regions if the project had not been built. This is true, for example, of the hunting and fishing activity of that portion of the mine's labor force which migrates from other regions in the province. For this redistributed recreation activity, no net increase in value can be attributed. The estimated net result of all these factors is that the 1980 angler and hunter-day estimates will hold steady throughout the period. In conjunction with the declining quality of the hunting and fishing experience. the range of hunter-day values drops to $12.00 to $17.00 per day and $4.00 to $6.00 for an angler day. Table VII details the calculation of recreation benefits with the project. It is assumed that management costs would remain the same whether or not the project proceeds.

3.4.3.2 Potential Loss of Timber Value

The site of the mine and processing plant is covered with timber which is presently scheduled for logging in approximately fifteen years. It is anticipated that logging would be at the rate of 1600 acres per year. The development of the site will mean that some of the timber will be cut prior to its scheduled age of cutting which it shall be assumed will result in some loss of net value. The 'without the project' case may be evaluated by calculating the net value of this logging and compounding the annual values forward to year 20. See Table IV.

Over the next twenty years approximately eight thousand acres of timberland would be disturbed in order to carry forward the proposed project. This land holds an average of thirty-five cunits of timber per acre at maturity and at a local mill is worth approximately $55.00 per cunit as sawlogs. It costs an average of $35.00 per cunit to log in this area and the log transport costs to the mill add another $10.00 per cunit. If the timber is evenly distributed over the area, is mature in 100 years, and grows at an average annual rate of 0.35 cunits per acre, per year, in 1980 there would be an average of 29.75 cunits on each acre.

If the mine is developed on a smooth, continuous basis, there will be four hundred acres (8,000 acres ÷ 20 years) developed each year. The quantity of timber on each of these acres will grow through time adding an average of 0.35 cunits per acre, per year. Table IX details the calculation of the net value of the forestry resource assuming the project is put in place, while Table VIII shows the without the project analysis.

Perusal of Tables VIII and IX indicates that, in fact, the development of the mine actually results in a net increase in the future value resulting from timber production as compared to the 'without-the-project' planned scheduling of this stand of timber. Even though some wood volume is sacrificed by harvesting before the planned age, the net returns from the smaller but earlier harvest at interest are greater than the net returns of the larger but later harvest.

3.5 Summary of the Provincial Income Account

Tables XIII through XVIII summarize the foregoing information for the development options and detail the application of the normalization procedure. Table XVIII shows the calculation of the normalization factors for the 75,000 tons per year and 100,000 tons per year plants. Calculation of the factor amounts to forming a ratio of the terminal value of outlays for each of the projects. This factor is then applied to the gross benefits and total costs of the project whose scale is to be normalized to that of the others. In this example, it has been assumed that the total outlays for the capital intensive project are the total capital available at 1980 and over the life span of the project without additional borrowing or increasing of taxes. Thus we have normalized the labor intensive project by adjusting its terminal benefit and cost estimates downward by the factors 0.83 and 0.74 for the 75,000 tons per year and 100,000 tons per year plants, respectively.

Applying these factors to the unnormalized terminal values of the LI project shown in Table XIV results in the normalized terminal benefit and cost estimates for this project shown on Table XV. The terminal values of the gross benefits and costs of the CI alternative are found in Table XVI. Comparing the normalized terminal values of net benefits for the different sales program/plant sizes for the LI alternative and the terminal values of net benefits for the different sales program/plant sizes for the CI alternative, we find that at a 10% discount rate the project which maximizes the provincial income account is the 75,000 tons per year plant with sales program 1. This conclusion is reached whether we use the TV(NB) or the benefit-cost ratio criterion.

3.6 Expenditures to meet Non-Efficiency Objectives

The government of Metroruritania has multiple objectives which it desires to meet partly through its economic development program. In this project in particular the government wishes to ensure that the people in the region are afforded the opportunity to participate in the general development if they so desire. Thus the government and Amalgam in conjunction develop an educational and training program designed to ensure that the local people have the capability to seize the opportunity. The benefits of this program are difficult to enumerate in monetary terms but the costs of developing and operating the program can be estimated with some accuracy. This program could be operated if either the capital or the labor intensive project is chosen as the one to be developed.

Experts estimate that the cost of the program would be $9,500,000 for the capital intensive program and $12,000,000 for the labor intensive alternative, both figures in year 2,000 terminal values compounded at 10%. Both these figures include estimates of the number of people who would participate in the program.

The government of Metroruritania also has the objective of maintaining or improving the social well-being of its residents. One specific aspect of this concern is the interest in improving the industrial safety record. The expenditures detailed in the Provincial Income account include the construction of mine and plant to meet the requirements of the Mine Safety Act and regulations attendant to it. However, this legislation is somewhat dated and recent advances have been made in safety technology which would require additional expenditures. In addition the company could conduct an in-plant safety education program on a continuing basis. The additional expenditures to implement the new safety technology amount to a terminal value in year 2,000 at a 10% discount rate of $2.5 million for the capital intensive plan and $1.2 million for the labor intensive plan. The safety education program would cost $200,000 for the capital intensive plan and $350,000 for the labor intensive plan in terminal value figures in year 2,000 compounded at 10%.

Finally, in conjunction with the government's desire to increase employment in this region it may wish to weight to some extent the degree to which these different relative factor intensities achieve that objective. Thus, presumably, the labor intensive project would receive additional 'marks' based on the extent to which government felt that this was desirable. It might be that the government would be willing to sacrifice the approximately $26.0 million excess of net benefits of the capital intensive project over the labor intensive project in order that the latter could contribute additionally to the achievement of the employment/regional development objective.

Table XVII summarizes the additional expenditures discussed in this section. In addition the increased employment of the labor intensive alternative is shown.

3.7 Summation

Decision makers in Metroruritania now have enough information before them to determine whether the project is sufficiently socially profitable and in which of its several forms it should be developed if at all. While the benefit-cost analysis is now complete and a decision may be made on the project there is still considerable analysis required to be performed in order that decision makers in Metroruritania are fully informed on the effects of the project. The following additional analyses should be conducted as adjuncts to the benefit-cost analysis proper.

(i) analysis of the income distributional effects of the project

(ii) analysis of the effect of the project on the cash flow or revenue/expenditure position of the Metroruritanian government

(iii) analysis of the foreign exchange impact of the project (from a national perspective)

Major elements of each of these additional analyses shall be described in turn.

The income redistributional impact of the project should be given considerable attention so as to insure that the government's income distributional objectives are realized. This analysis would identify Metroruritanian residents roughly by socio-economic characteristics and would record the anticipated net effect of the project on the individual's or group's income and opportunity position. Much of this analysis would depend upon the financial structure of Amalgam - whether debt or equity - and the geographical location of shareholders and creditors, upon the type and level of schemes to recover resource rent and upon the sharing of the financial burden of aspects of the development (social infrastructure) finally agreed upon by both Metroruritania and Amalgam.

In this respect it is notable that the benefit-cost analysis does not separate the financial burden of the development between Amalgam and the Metroruritanian government. This is a matter for negotiation between the two institutions. The outcome of the negotiations will clearly affect the financial flows which the two entities will experience. Just as Amalgam will conduct a cash flow analysis of the project so should the government analyze the effect of the project on its cash flow or revenue/expenditure position. The government will also take into consideration the revenues derived from a resource rent appropriation scheme as well as additional corporate income tax revenues it will derive.

Finally, the national government of which Metroruritania is a part will be interested in the requirements for foreign exchange necessitated by the development of the Skunk deposits. The development will be both a source and a use of foreign exchange and the net effect will have an impact on the country's balance of payments. Metroruritania will assist in this analysis.

TABLE I

SALES PROGRAM FOR EACH SALES FORECAST
BY PRODUCTION TECHNOLOGY
1980-2000
(Thousands of Tons Per Year)

	1980	1981	1982	1983	1984-1990	1991-2000
Alternatives CI1, LI1						
Sales In:						
Domestic Market	30	30	30	30	30	30
Export Market	10	20	35	40	45	45
Totals	40	50	65	70	75	75
Alternatives CI2, LI2						
Sales In:						
Domestic Market	30	30	30	30	30	30
Export Market	10	20	35	40	45	70
Totals	40	50	65	70	75	100
Alternatives CI3, LI3						
Sales In:						
Domestic Market	30	30	30	30	30	30
Export Market	-	-	-	-	-	-
Totals	30	30	30	30	30	30

TABLE II

ANNUAL GROSS BENEFITS OF EACH SALES PROGRAM/PRODUCTION PROCESS ALTERNATIVE

(Thousands of 1976 Dollars)

	1980	1981	1982	1983	1984-1990	1991-2000
Alternatives CI1, LI1						
Domestic Sales	$690	$ 690	$ 690	$ 690	$ 690	$ 690
Export Sales	250	500	875	1,000	1,125	1,125
Economic Rent on Domestic Sales	45	45	45	45	45	45
Total Gross Benefits	$985	$1,235	$1,610	$1,735	$1,860	$1,860
Alternatives CI2, LI2						
Domestic Sales	$690	$ 690	$ 690	$ 690	$ 690	$ 690
Export Sales	250	500	875	1,000	1,125	1,750
Economic Rent on Domestic Sales	45	45	45	45	45	45
Total Gross Benefits	$885	$1,235	$1,610	$1,735	$1,860	$2,485
Alternatives CI3, LI3						
Domestic Sales	$690	$ 690	$ 690	$ 690	$ 690	$ 690
Export Sales	-	-	-	-	-	-
Economic Rent on Domestic Sales	45	45	45	45	45	45
Total Gross Benefits	$735	$ 735	$ 735	$ 735	$ 735	$ 735

TABLE III A

INVESTMENT OUTLAYS - ALTERNATIVE CI
(Thousands of Dollars)

	Total Investment	Amount Payable In Domestic Currency	Amount Payable In Foreign Currency
Civil Engineering and Building Work	$ 220	$220	
Equipment	1,600	400	$1,200
Offices	220	145	75
Stocks	265		265
Housing and Amenities	240	165	75
Totals	$2,545	$930	$1,615

TABLE III B

INVESTMENT OUTLAYS - ALTERNATIVE LI
(Thousands of Dollars)

	Total Investment	Amount Payable In Domestic Currency	Amount Payable In Foreign Currency
Civil Engineering and Building Work	$ 200	$200	
Equipment	950	313	$ 637
Offices	220	145	75
Stocks	265		265
Housing and Amenities	300	225	75
Totals	$1,935	$883	$1,052

TABLE IV A

TIMING OF INVESTMENT OUTLAYS - ALTERNATIVE CI
(Thousands of Dollars)

	1976	1977	1978	1979	1990
Civil Engineering and Building		$220			
Equipment		700	$600		$300
Offices			200		
Stocks				$200	65
Housing and Amenities				240	
Totals		$920	$820	$440	$365

TABLE IV B

TIMING OF INVESTMENT OUTLAYS - ALTERNATIVE LI
(Thousands of Dollars)

	1976	1977	1978	1979	1980
Civil Engineering and Building		$200			
Equipment		400	$400		$150
Offices			220		
Stocks				$200	65
Housing and Amenities				300	
Totals		$600	$620	$500	$215

TABLE V A

ANNUAL OPERATING COSTS FOR AN OUTPUT OF 75,000 TONS PER YEAR - ALTERNATIVE CI[4]

(Thousands of 1976 Dollars)

	1980	1981	1982	1983	1984-2000
Wages (Operation and Maintenance)[1]	$110	$113	$116	$118	$118
Operational Supplies	50	50	50	50	50
Fuel Oil[2]	150	158	166	174	(t-1) (1+0.05)
Maintenance[3]	50	53	56	60	(t-1) (1+0.06)
Salaries - Management and Professional	40	40	40	40	40
Offices and Miscellaneous	50	50	50	50	50
Totals	$450	$464	$478	$492	-

TABLE V B

ANNUAL OPERATING COSTS FOR AN OUTPUT OF 100,000 TONS PER YEAR - ALTERNATIVE CI[4]

(Thousands of 1976 Dollars)

	1980	1981	1982	1983	1984-2000
Wages (Operation and Maintenance)[1]	$150	$154	$158	$162	$162
Operational Supplies	70	70	70	70	70
Fuel Oil[2]	200	210	221	232	(t-1) (1+0.05)
Maintenance[3]	70	74	77	81	(t-1) (1+0.06)
Salaries - Management and Professional	40	40	40	40	40
Offices and Miscellaneous	50	50	50	50	50
Totals	$580	$598	$616	$635	0

TABLE VI A

ANNUAL OPERATING COSTS FOR
AN OUTPUT OF 75,000 TONS PER YEAR - ALTERNATIVE LI[4]
(Thousands of 1976 Dollars)

	1980	1981	1982	1983	1984-2000
Wages (Operation and Maintenance)[1]	\$332	\$340	\$349	\$358	\$366
Operational Supplies	45	45	45	45	45
Fuel Oil[2]	112	118	123	130	(t-1) (1+0.05)
Maintenance[3]	45	48	51	54	(t-1) (1+0.06)
Salaries - Management and Professional	81	81	81	81	81
Offices and Miscellaneous	60	60	60	60	60
Totals	\$675	\$692	\$709	\$728	-

TABLE VI B

ANNUAL OPERATING COSTS FOR
AN OUTPUT OF 100,000 TONS PER YEAR - ALTERNATIVE LI[4]
(Thousands of 1976 Dollars)

	1980	1981	1982	1983	1984-2000
Wages (Operation and Maintenance)[1]	\$440	\$451	\$462	\$474	\$486
Operational Supplies	60	60	60	60	60
Fuel Oil[2]	150	158	165	174	(t-1) (1+0.05)
Maintenance[3]	60	64	67	71	(t-1) (1+0.06)
Salaries - Management and Professional	110	110	110	110	110
Offices and Miscellaneous	80	80	80	80	80
Totals	\$900	\$923	\$944	\$969	-

NOTES TO TABLES V AND VI

[1] The Wage Bill is estimated to grow at the rate of 2.5% per year during the period 1980-1983, inclusive. This is based upon an analysis of relative wage trends in selected industries which employ the same basic types of labor. This 2.5% relative increase is a combination of a relative increase in productivity per worker and increased derived demand due to increasing demand for the products made by this labor type. This increase is forecast through 1983 but beyond that year there is no information which suggests that the relative increase will continue. Hence the Wage Bill is constant in real terms 1984-2000.

[2] Estimated to increase at the annual rate of 5% per year, compounded. This estimate is based on the objectives of a federal government program to bring the nominal price of oil up to world levels. While the nominal price of oil will increase more than 5% per year, other manufacturing costs will rise at a nominal rate which reduces the real oil price increase to 5%.

[3] Maintenance expenses will rise at a steady compound rate of 6% per annum due largely to continuous aging of the machinery and equipment.

[4] The 100,000 t.p.y. plant requires some structural changes which add 50 cents/ton to the operating costs of the capital intensive alternative and $1.00/ton to the operating costs of the labor intensive alternative.

TABLE VII

CALCULATION OF TERMINAL VALUE OF WILDLIFE-BASED RECREATION
(1980-2000)

	Without the Project							With the Project						
					Terminal Value in Year 20 at 5%							Terminal Value in Year 20 at 5%		
Year	Hunter Days[1]	Annual Hunting Value[2]	Angler Days[1]	Annual Fishing Value[2]	Value of Hunting	Value of Fishing	Total	Hunter Days[1]	Annual Value[2]	Angler Days[1]	Annual Value[2]	Value of Hunting	Value of Fishing	Total
1980	600	$ 10,200	300	$ 2,100	$ 23,880	$ 3,980	$ 27,860	600	$ 9,000	300	$ 1,500	$ 27,064	$ 5,572	$ 32,636
1981	600	10,200	300	2,100	22,743	3,790	26,533	600	9,000	300	1,500	25,775	5,307	31,082
1982	609	10,353	305	2,135	21,660	3,610	25,270	600	9,000	300	1,500	24,916	5,138	30,054
1983	618	10,506	309	2,163	20,628	3,438	24,066	600	9,000	300	1,500	24,080	4,958	29,038
1984	627	10,659	314	2,198	19,646	3,274	22,920	600	9,000	300	1,500	23,267	4,798	28,065
1985	637	10,829	318	2,226	18,710	3,118	21,828	600	9,000	300	1,500	22,513	4,628	27,141
1986	646	10,982	323	2,261	17,879	2,970	20,849	600	9,000	300	1,500	21,744	4,477	26,221
1987	656	11,152	328	2,296	16,971	2,820	19,791	600	9,000	300	1,500	21,029	4,329	25,358
1988	666	11,322	333	2,331	16,163	2,694	18,857	600	9,000	300	1,500	20,333	4,186	24,519
1989	675	11,492	338	2,366	15,393	2,566	17,959	600	9,000	300	1,500	19,655	4,047	23,702
1990	686	11,662	343	2,401	14,660	2,443	17,103	600	9,000	300	1,500	18,996	3,911	22,907
1991	696	11,832	348	2,436	13,962	2,327	16,289	600	9,000	300	1,500	18,355	3,779	22,134
1992	707	12,019	353	2,471	13,297	2,216	15,513	600	9,000	300	1,500	17,759	3,651	21,410
1993	717	12,189	359	2,513	12,664	2,111	14,775	600	9,000	300	1,500	17,151	3,536	20,687
1994	728	12,376	364	2,548	12,061	2,010	14,071	600	9,000	300	1,500	16,585	3,415	20,000
1995	739	12,563	370	2,590	11,487	1,914	13,401	600	9,000	300	1,500	16,034	3,305	19,339
1996	750	12,750	375	2,625	10,940	1,823	12,763	600	9,000	300	1,500	15,498	3,191	18,689
1997	761	12,937	381	2,667	10,419	1,736	12,155	600	9,000	300	1,500	14,976	3,087	18,063
1998	773	13,[illegible]	386	2,702	9,923	1,654	11,577	600	9,000	300	1,500	14,488	2,979	17,467
1999	784	13,[illegible]	392	2,744	9,450	1,575	11,025	600	9,000	300	1,500	13,994	2,881	16,875
2000	796	13,532	398	2,786	9,000	1,500	10,500	600	9,000	300	1,500	13,532	2,786	16,318
Totals	14,472	$246,024	7,237	$50,659	$321,536	$53,569	$375,105	12,600	$189,000	6,300	$31,500	$407,744	$83,961	$491,705

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[1] See text Section 3.4.1 for rationale behind calculation of hunter-days and angler-days.

[2] Daily hunter and angler values taken as the midpoint of each range. $15.00/day for hunting and $5.00 per day for angling.

TABLE VIII

CALCULATION OF VALUE TERMINAL OF TIMBER PRODUCTION WITHOUT THE PROJECT

(1980-2000)

Year	Acres Logged	Cunits Logged[1]	Gross Value	Less Costs[2]	Net Value	Terminal Value in Year Twenty At: 8%	Terminal Value in Year Twenty At: 10%	Terminal Value in Year Twenty At: 12%
1995	1,600	56,000	$ 3,080,000	$ 2,520,000	$ 560,000	$ 822,823	$ 901,885	$ 986,911
1996	1,600	56,000	3,080,000	2,520,000	560,000	761,874	819,896	881,171
1997	1,600	56,000	3,080,000	2,520,000	560,000	705,438	745,360	786,760
1998	1,600	56,000	3,080,000	2,520,000	560,000	653,184	677,600	702,464
1999	1,600	56,000	3,080,000	2,520,000	560,000	604,800	616,000	627,200
Totals	8,000	280,000	$15,400,000	$12,600,000	$2,800,000	$3,548,119	$3,760,741	$3,984,506

[1] Assumes 35 cunits per acre.

[2] Logging costs of $35.00 per cunit plus transport costs of $10.00 per cunit.

TABLE IX

CALCULATION OF TERMINAL VALUE OF TIMBER PRODUCTION WITH THE PROJECT

(1980-2000)

Year	Acres Logged	Cunits Per Acre	Total Cunits	Gross Value	Less Costs	Net Value	Terminal Value in Year Twenty At:		
							8%	10%	12%
1980	400	29.75	11,900	$ 654,500	$ 535,500	$ 119,000	$ 554,654	$ 800,572	$ 1,147,908
1981	400	30.10	12,040	662,200	541,800	120,400	519,610	736,355	1,036,977
1982	400	30.45	12,180	669,900	548,100	121,800	486,715	677,198	936,638
1983	400	30.80	12,320	677,600	554,400	123,200	455,842	622,711	845,896
1984	400	31.15	12,460	685,300	560,700	124,600	426,872	572,534	763,847
1985	400	31.50	12,600	693,000	567,000	126,000	399,693	528,004	689,669
1986	400	31.85	12,740	700,700	573,300	127,400	374,198	483,802	622,618
1987	400	32.20	12,880	708,400	579,600	128,800	350,288	444,653	562,018
1988	400	32.25	12,900	709,500	580,500	129,000	324,844	404,857	502,581
1989	400	32.90	13,160	723,800	592,200	131,600	306,844	375,470	457,777
1990	400	33.25	13,300	731,500	598,500	133,000	287,137	344,967	413,078
1991	400	33.60	13,440	739,200	604,800	134,400	263,666	316,908	372,702
1992	400	33.95	13,580	746,900	611,100	135,800	251,356	291,099	336,236
1993	400	34.30	13,720	754,600	617,400	137,200	235,137	267,364	303,305
1994	400	34.65	13,360	762,300	623,700	138,600	219,941	245,538	273,572
1995	1,600	35.00	56,000	3,080,000	2,520,000	560,000	822,824	901,886	986,911
1996	400	35.00	14,000	770,000	630,000	140,000	190,468	204,974	220,293
1997	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-
Totals	8,000		263,080	$14,469,400	$11,838,600	$2,630,800	$6,474,729	$8,218,892	$10,472,026

TABLE X

TERMINAL VALUE OF GROSS BENEFITS
FOR THREE SALES PROGRAMS
(1980-2000)
Thousands of 1976 Dollars

Year	Number of Years To 2000	Alternatives CI1, LI1				Alternatives CI2, LI2				Alternatives CI3, LI3			
		Annual Gross Benefits[1]	Future Value in Year 20			Annual Gross Benefits	Future Value in Year 20			Annual Gross Benefits	Future Value in Year 20		
			8%	10%	12%		8%	10%	12%		8%	10%	12%
1980	20	985	4,591	6,627	9,502	885	4,125	5,954	8,537	735	3,426	4,945	7,090
1981	19	1,235	5,330	7,553	10,637	1,235	5,330	7,553	10,637	735	3,172	4,495	6,330
1982	18	1,610	6,434	8,951	12,381	1,610	6,434	8,951	12,381	735	2,937	4,087	5,652
1983	17	1,735	6,420	8,770	11,913	1,735	6,420	8,770	11,913	735	2,720	3,715	5,047
1984	16	1,860	6,372	8,547	11,403	1,860	6,372	8,547	11,403	735	2,518	3,377	4,506
1985	15	1,860	5,900	7,770	10,181	1,860	5,900	7,770	10,181	735	2,332	3,070	4,023
1986	14	1,860	5,463	7,063	9,090	1,860	5,463	7,063	9,090	735	2,159	2,791	3,592
1987	13	1,860	5,059	6,421	8,116	1,860	5,059	6,421	8,116	735	1,999	2,537	3,207
1988	12	1,860	4,684	5,837	7,247	1,860	4,684	5,837	7,247	735	1,851	2,307	2,864
1989	11	1,860	4,337	5,307	6,470	1,860	4,337	5,307	6,470	735	1,714	2,097	2,557
1990	10	1,860	4,016	4,824	5,777	1,860	4,016	4,824	5,777	735	1,587	1,906	2,283
1991	9	1,860	3,718	4,386	5,178	2,485	4,968	5,860	6,891	735	1,469	1,733	2,038
1992	8	1,860	3,443	3,987	4,605	2,485	4,600	5,327	6,153	735	1,360	1,576	1,820
1993	7	1,860	3,188	3,625	4,112	2,485	4,259	4,843	5,494	735	1,260	6,973	1,625
1994	6	1,860	2,952	3,295	3,671	2,485	3,943	4,402	4,905	735	1,166	1,302	1,451
1995	5	1,860	2,733	2,996	3,278	2,485	3,651	4,002	4,379	735	1,080	1,184	1,295
1996	4	1,860	2,531	2,723	2,927	2,485	3,381	3,638	3,910	735	1,000	1,076	1,157
1997	3	1,860	2,343	2,476	2,613	2,485	3,130	3,308	3,491	735	926	1,233	1,033
1998	2	1,860	2,170	2,251	2,333	2,485	2,899	3,007	3,117	735	857	1,037	922
1999	1	1,860	2,009	2,046	2,083	2,485	2,684	2,734	2,783	735	794	809	823
2000	0	1,860	1,860	1,860	1,860	2,485	2,485	2,485	2,485	735	735	735	735
Totals		37,185	85,553	107,315	135,377	43,335	94,140	116,603	145,360	15,435	36,882	52,985	60,050

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[1] In thousands of 1976 dollars.

TABLE XI

TERMINAL VALUE OF OPERATING COSTS FOR BOTH OUTPUT LEVELS - ALTERNATIVE CI
(Thousands of 1976 Dollars)

Year	Years To Maturity	75,000 TPY	Terminal Value in Year 20 At			100,000 TPY	Terminal Value in Year 20 At		
		Annual Operating Cost	8%	10%	12%	Annual Operating Cost	8%	10%	12%
1980	20	450	2,097	3,027	4,341	580	2,703	3,902	5,595
1981	19	464	2,002	2,838	3,996	598	2,581	3,657	5,150
1982	18	478	1,910	2,658	3,676	616	2,462	3,425	4,737
1983	17	492	1,820	2,487	3,378	635	2,350	3,210	4,360
1984	16	504	1,727	2,316	3,090	656	2,247	3,014	4,022
1985	15	517	1,640	2,160	2,830	673	2,135	2,811	3,684
1986	14	531	1,560	2,016	2,595	692	2,033	2,628	3,382
1987	13	545	1,482	1,881	2,378	711	1,934	2,455	3,102
1988	12	560	1,410	1,758	2,182	732	1,843	2,297	2,852
1989	11	576	1,343	1,643	2,004	753	1,756	2,148	2,619
1990	10	593	1,280	1,538	1,842	776	1,675	2,013	2,410
1991	9	616	1,231	1,453	1,708	800	1,599	1,886	2,218
1992	8	629	1,164	1,348	1,557	826	1,529	1,771	2,045
1993	7	649	1,112	1,265	1,435	852	1,460	1,660	1,834
1994	6	670	1,063	1,187	1,322	880	1,396	1,559	1,737
1995	5	691	1,015	1,113	1,218	910	1,337	1,466	1,604
1996	4	714	971	1,045	1,123	941	1,280	1,378	1,481
1997	3	738	930	982	1,037	974	1,227	1,296	1,368
1998	2	763	890	923	957	1,008	1,176	1,220	1,264
1999	1	790	853	869	885	1,044	1,128	1,148	1,169
2000	0	818	818	818	818	1,083	1,083	1,083	1,083
Totals		12,788	28,318	35,325	44,372	16,740	36,934	46,027	57,766

TABLE XII

TERMINAL VALUE OF OPERATING COSTS FOR BOTH OUTPUT LEVELS - ALTERNATIVE II
(Thousands of 1976 Dollars)

			Terminal Value in Year 20 At 75,000 TPY				Terminal Value in Year 20 At 100,000 TPY		
Year	Years To Maturity	Annual Operating Cost	8%	10%	12%	Annual Operating Cost	8%	10%	12%
1980	20	675	3,146	4,541	6,511	900	4,195	6,055	8,682
1981	19	692	2,986	4,232	5,960	923	3,983	5,645	7,950
1982	18	709	2,833	3,942	5,452	944	3,772	5,249	7,259
1983	17	728	2,694	3,680	4,998	969	3,585	4,898	6,653
1984	16	747	2,559	3,432	4,579	994	3,405	4,567	6,094
1985	15	756	2,398	3,158	4,138	1,008	3,198	4,211	5,517
1986	14	767	2,253	2,913	3,748	1,022	3,002	3,881	4,995
1987	13	778	2,116	2,685	3,395	1,037	2,820	3,580	4,525
1988	12	790	1,939	2,479	3,078	1,053	2,652	3,305	4,102
1989	11	803	1,872	2,291	2,793	1,070	2,495	3,053	3,722
1990	10	816	1,762	2,116	2,534	1,088	2,349	2,822	3,379
1991	9	830	1,659	1,957	2,302	1,106	2,211	2,608	3,067
1992	8	843	1,560	1,807	2,087	1,126	2,084	2,414	2,788
1993	7	860	1,474	1,676	1,901	1,147	1,966	2,235	2,536
1994	6	877	1,392	1,554	1,731	1,168	1,853	2,069	2,305
1995	5	894	1,314	1,440	1,576	1,191	1,750	1,918	2,099
1996	4	912	1,241	1,335	1,435	1,216	1,654	1,780	1,913
1997	3	931	1,173	1,239	1,308	1,241	1,563	1,652	1,744
1998	2	952	1,110	1,152	1,194	1,267	1,478	1,533	1,589
1999	1	981	1,059	1,079	1,099	1,296	1,400	1,426	1,452
2000	0	1,104	1,104	1,104	1,104	1,327	1,327	1,327	1,327
Totals		17,445	39,694	49,813	62,923	23,093	52,742	66,228	83,698

TABLE XIII

TERMINAL VALUE OF CAPITAL COSTS FOR ALTERNATIVE CI

(Thousands of 1976 Dollars)

Years To Maturity	Year	Yearly Outlay	Terminal Value in Year 20 At 8%	10%	12%
24	1976	-			
23	1977	920	5,401	8,237	12,468
22	1978	820	4,458	6,675	9,922
21	1979	440	2,215	3,256	4,754
20	1980	-			
19	1981	-			
18	1982	-			
17	1983	-			
16	1984	-			
15	1985	-			
14	1986	-			
13	1987	-			
12	1988	-			
11	1989	-			
10	1990	365	788	947	1,134
9	1991	-			
8	1992	-			
7	1993	-			
6	1994	-			
5	1995	-			
4	1996	-			
3	1997	-			
2	1998	-			
1	1999	-			
0	2000	-			
Totals		2,545	12,862	19,115	28,272

TABLE XIV

TERMINAL VALUE OF CAPITAL COSTS FOR ALTERNATIVE LI
(Thousands of 1976 Dollars)

Years To Maturity	Year	Yearly Outlay	Terminal Value in Year 20 At		
			8%	10%	12%
24	1976	-			
23	1977	600	3,523	5,373	8,131
22	1978	620	3,371	5,047	7,502
21	1979	500	2,517	3,700	5,402
20	1980	-			
19	1981	-			
18	1982	-			
17	1983	-			
16	1984	-			
15	1985	-			
14	1986	-			
13	1987	-			
12	1988	-			
11	1989	-			
10	1990	215	464	558	668
9	1991	-			
8	1992	-			
7	1993	-			
6	1994	-			
5	1995	-			
4	1996	-			
3	1997	-			
2	1998	-			
1	1999	-			
0	2000	-			
Totals		1,935	9,875	14,678	21,703

TABLE XV

ALTERNATIVE LI
SUMMARY OF PROVINCIAL INCOME ACCOUNT
TERMINAL VALUES IN THOUSANDS OF 1976 DOLLARS

	Sales Program 1			Sales Program 2			Sales Program 3		
	8%	10%	12%	8%	10%	12%	8%	10%	12%
Terminal Value of Gross Benefits: TV(B)	85,553	107,315	135,377	94,140	116,603	145,360	36,882	52,985	60,050
Terminal Value of Costs:									
Terminal Value of Capital Costs	9,875	14,678	21,703	9,875	14,678	21,703	9,875	14,678	21,703
Terminal Value of Operating Costs	39,694	49,813	62,923	52,742	66,228	83,698	39,694	49,813	62,923
Terminal Value of Other Resource Uses Foregone									
- Wildlife Based Recreation[2]	117	117	117	117	117	117	117	117	117
- Forestry[1]	(2,925)	(4,458)	(6,483)	(2,926)	(4,458)	(6,488)	(2,926)	(4,488)	(6,488)
Total Terminal Value of Costs: TV(C)	46,760	60,150	78,255	59,808	76,565	99,030	46,760	60,150	78,255
Terminal Value of Net Benefits: TV(NB)	38,793	47,165	57,122	34,332	40,038	46,330	(9,678)	(7,165)	(18,205)

[1] A reduction of costs.

[2] Compounded at the assumed rate of social time preference of 5%.

TABLE XVI

ALTERNATIVE LI
SUMMARY OF PROVINCIAL INCOME ACCOUNT
NORMALIZED TERMINAL VALUES IN THOUSANDS OF 1976 DOLLARS

	Sales Program 1			Sales Program 2			Sales Program 3		
	8%	10%	12%	8%	10%	12%	8%	10%	12%
Normalized Terminal Value of Gross Benefits: TV(B)	71,008	89,071	112,362	74,371	92,116	114,834	30,612	43,978	49,842
Normalized Terminal Value of Costs:									
Normalized Terminal Value of Capital Costs	8,196	12,183	18,013	7,801	11,596	17,145	8,196	12,183	18,013
Normalized Terminal Value of Operating Costs	32,946	41,345	52,226	41,666	52,320	66,121	32,946	41,345	52,226
Normalized Terminal Value of Other Resource Uses Foregone									
- Wildlife Based Recreation[2]	97	97	97	92	92	92	97	97	97
- Forestry[1]	(2,429)	(3,700)	(5,385)	(2,312)	(3,522)	(5,126)	(2,429)	(3,700)	(5,385)
Total Normalized Terminal Value of Costs: TV(C)	38,810	49,925	64,951	47,247	60,486	78,232	38,810	49,925	64,951
Normalized Terminal Value of Net Benefits: TV(B)	32,198	39,146	47,411	27,124	31,630	36,602	(8,198)	(5,947)	(15,109)
Benefit-Cost Ratio (TV(B)/TV(C))	1.83:1.0	1.78:1.0	1.73:1.0	1.57:1.0	1.52:1.0	1.47:1.0	0.79:1.0	0.88:1.0	0.77:1.0

[1] A reduction of costs.

[2] Compounded at the assumed rate of social time preference of 5%.

TABLE XVII

ALTERNATIVE CI
SUMMARY OF PROVINCIAL INCOME ACCOUNT
TERMINAL VALUES IN THOUSANDS OF 1976 DOLLARS

	Sales Program 1			Sales Program 2			Sales Program 3		
	8%	10%	12%	8%	10%	12%	8%	10%	12%
Terminal Value of Gross Benefits: TV(B)	85,553	107,315	135,377	94,140	116,603	145,360	36,882	52,985	60,050
Terminal Value of Costs									
Terminal Value of Capital Costs	12,862	19,115	28,272	12,862	19,115	28,272	12,862	19,115	28,272
Terminal Value of Operating Costs	28,318	35,325	44,372	36,934	46,027	57,766	28,318	35,325	44,372
Terminal Value of Other Uses Foregone:									
- Wildlife Based Recreation[2]	117	117	117	117	117	117	117	117	117
- Forestry[1]	(2,926)	(3,458)	(6,488)	(2,926)	(3,458)	(6,488)	(2,926)	(3,458)	(6,488)
Total Terminal Value of Costs: TV(C)	38,371	51,099	66,273	46,987	61,801	79,667	38,371	51,099	66,273
Terminal Value of Net Benefits (TV(NB))	47,182	56,216	69,104	47,153	54,802	65,693	(1,489)	1,886	(6,223)
Benefit-Cost Ratio: (TV(B)/TV(C))	2.23:1.0	2.10:1.0	2.04:1.0	2.00:1.0	1.89:1.0	1.82:1.0	0.96:1.0	1.04:1.0	0.91:1.0

[1] A reduction of costs.

[2] Compounded at the assumed rate of social time preference of 5%.

TABLE XVIII

CALCULATION OF NORMALIZATION FACTOR FOR LABOR INTENSIVE ALTERNATIVE

	8%		10%	
TERMINAL VALUE OF CI OUTLAYS:	75,000TPY	100,000TPY	75,000TPY	100,000TPY
Operating Cost	28,318	36,934	35,325	46,027
Capital Cost	12,862	12,862	19,115	19,115
Other Resource Uses Foregoing				
Wildlife Based Recreation	117	117	117	117
Forestry	2,926	2,926	4,458	4,458
TOTALS	38,371	46,987	50,099	60,801
TERMINAL VALUE LI OUTLAYS:				
Operating Cost	39,694	52,742	49,813	66,228
Capital Cost	9,875	9,875	14,678	14,678
Other Resource Uses Foregoing				
Wildlife Based Recreation	117	117	117	117
Forestry	(2,926)	(2,926)	(4,458)	(4,458)
TOTALS	46,760	59,808	60,150	76,565
TERMINAL VALUE OF LI OUTLAY: TERMINAL VALUE OF CI OUTLAY	0.83	0.79	0.83	0.79

TABLE XIX

EXPENDITURES AND ADJUSTMENTS TO PROJECTS TO MEET NON-INCOME OBJECTIVES TERMINAL VALUES IN THOUSANDS OF 1976 DOLLARS

	Capital Intensive Plan	Labor Intensive Plan
Education and Labor Retraining	$ 9,500	$12,000
Implementing Safety Technology:		
Increased Capital and Operating Expense	2,500	1,200
Safety Education Program	200	350
Total Expenditures	$12,200	$13,550
Additional Employment in Man-Years per Year	-	200